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PRELIMINARY EVALUATION OF REMEDIAL ALTERNATIVES

MAIN DOCK TANK FARM ANNETTE ISLAND, ALASKA

DRAFT JANUARY 2000

Prepared for:
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Total Environmental Restoration Contract
Contract No. DACA 85-95-D-0018
Task Order No. 14

TABLE OF CONTENTS

TABLES

TABLE OF CONTENTS

SECTION **PAGE**

FIGURES

APPENDIX

ACRONYMS AND ABBREVIATIONS

AST	above-ground storage tank
bgs	below ground surface
CAA	Civil Aeronautics Administration
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
gpm	gallons per minute
HAVE	hot air vapor extraction
MIC	Metlakatla Indian Community
O&M	operation and maintenance
PCBs	polychlorinated biphenyls
PRGs	preliminary remediation goals
RAO	remedial action objective
RACER	Remedial Action Cost Engineering and Requirements System
TERC	Total Environmental Restoration Contract
TPH	total petroleum hydrocarbons
USCG	U.S. Coast Guard
USAED	U.S. Army Engineer District, Alaska
VOC	volatile organic compound

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EXECUTIVE SUMMARY

This document presents preliminary cleanup options that could be applied at the Main Dock Tank Farm at the Annette Island Airport, Annette Island, Alaska. Cleanup options are being considered because past releases of fuels might be posing unacceptable risks to people or the environment. To help determine the best cleanup options, results from past sampling events have been summarized and are compared to cleanup levels derived by the Metlakatla Indian Community (MIC). In addition, these results are also compared to cleanup levels developed by U.S. Environmental Protection Agency (EPA).

The cleanup options identified in this document will be used for budgeting purposes and to help scientists and engineers collect other information needed to complete the cleanup of the tank farm. This information will be used to help select a cleanup option that can be used at the Main Dock Tank Farm. Therefore, this document is considered a "living document" that will be modified to incorporate new information as it becomes available.

The Main Dock Tank Farm was built in the early 1940s to store and route fuel to storage tanks in support of airfield operations for WWII. Several parties either owned or operated the tank farm, including the U.S. Army, Standard Oil, the MIC, and the Civil Aeronautics Administration (CAA), predecessor to the Federal Aviation Administration (FAA). During the tank farm's operational period, about 500,000 to 1,500,000 gallons of fuel were used each year. Operation of the tank farm stopped in 1977.

Fuel in soil and groundwater likely originated from past tank farm operation. Review of historical information and interviews with personnel familiar with the site and its history have indicate that fuel entered soil and groundwater from the following activities:

- Tank overflows during filling;
- Accidental pipeline breaks;
- Fuel spills during facility repairs or modifications;
- Routine draining of water from the tanks; and
- Routine tank cleaning.

Based on available information, cleanup activities will be aimed at removing gasoline, jet fuel, and heating oil from soil and groundwater. However, not all of the information needed to cleanup the tank farm has been collected, so the FAA is planning to collect more information this summer (summer of 2000).

Cleanup options were developed to protect people and the environment from fuel-related compounds at the tank farm. Objectives developed to support this goal are as follows:

- Reduce potential risk by removing or containing site contaminants; and
- Comply with cleanup levels mandated by the MIC.

Cleanup options were selected using a process developed by the EPA. This process begins by looking at all available cleanup options and narrowing down the list to those options that are best suited to clean up the site. To help narrow down the list of cleanup options, screening criteria were used. These criteria were developed to help identify which technologies would best satisfy the overall remedial approach for the site (as discussed in Section 2). These criteria are as follows:

- The option would be effective at the tank farm;
- The option has been used in Alaska at other sites;
- The option would meet the cleanup objectives;
- The option is cost effective; and
- There is an anticipated community preference for a cleanup option, such as creating jobs or having little effect on the existing environment (i.e., not having to cut down large trees).

Based on these criteria, several cleanup options have been identified, and are presented in Table ES-1.

Table ES-1
Main Dock Tank Farm Preliminary Cleanup Options

Soil	Beach Sediment	Water
1. Access restrictions with monitored natural attenuation	1. Access restrictions with monitored natural attenuation	1. Access restrictions with monitored natural attenuation
2. Excavation, thermal desorption, backfill excavation	2. Beach excavation, sediment dewatering, sediment treatment, water treatment	2. Interception trench, constructed wetlands treatment, underground injection
3. Excavation, composting, onsite disposal	3. In situ landfarming	3. Interception trench, carbon treatment, underground injection
4. Excavation, landfarming, onsite disposal		4. Surface water and shallow groundwater diversion
		5. In situ treatment using oxygen-releasing compounds

Each cleanup option was again compared to the screening criteria to help determine which option might be best suited for cleaning up the Main Dock Tank Farm. The evaluation uses the following scores to rank each cleanup option:

- The "👍" symbol means that the alternative meets the criteria;
- The "👌" symbol means that the alternative partially meets the criteria; and
- The "👎" symbol means that the alternative does not meet the criteria.

Table ES-2 presents the results of comparing each cleanup option to the screening criteria (Note: Table 3-15 in this document provides a detailed explanation of the scoring criteria).

Based on the information available at this time, the following cleanup options may be the best-suited to clean up soil, beach sediment, and water as follows:

- Soil – excavation of contaminated soil with composting;
- Beach sediment – excavation with treatment using the selected soil treatment option; and
- Water – treatment using a constructed wetlands and underground injection. Limited diversion of clean groundwater away from the treatment system is also recommended to help minimize the quantity of water requiring treatment.

Table ES-2
Comparative Evaluation of Remedial Alternatives

Remedial Alternative	Screening Criteria				
	Technically Implementable	Field Proven in Alaska	Cost Effective	Satisfies RAOs	Community Preference
Soil					
Access restrictions with monitored natural attenuation	👍	👍	👍	👌	👎
Excavate, thermal desorption, backfill excavation	👎	👍	👎	👍	👎
Excavate, composting, onsite disposal	👍	👌	👌	👌	👍
Excavate, land farming, onsite disposal	👌	👌	👌	👌	👍
Beach Sediment					
Access restrictions with monitored natural attenuation	👍	👍	👍	👌	👎
Excavation, sediment dewatering, sediment treatment, water treatment	👌	👌	👎	👍	👌
In situ landfarming	👍	👎	👌	👌	👎
Water					
Access restrictions with monitored natural attenuation	👍	👍	👍	👌	👎
Interception trench, constructed wetlands, underground injection	👌	👍	👎	👍	👍
Interception trench, carbon treatment, underground injection	👌	👍	👎	👍	👌
Water diversion	👌	👍	👌	👎	👌
In situ treatment using oxygen-releasing compounds	👍	👌	👎	👌	👎

The most cost-effective cleanup approach would involve implementing cleanup options for one medium (soil, sediment, or water) in a manner that minimizes the cost of cleaning up other media. For example, excavated areas could be converted into constructed wetlands treatment cells; the excavation costs between the two options would be shared, reducing the overall cleanup cost. Other ways to reduce cost will continue to be evaluated.

1.0 INTRODUCTION

This document presents the results of an evaluation of remedial alternatives that may be suitable to remediate portions of the Main Dock Tank Farm at the Annette Island Airport, Annette Island, Alaska. Possible remedial actions are being reviewed for the site due to potentially unacceptable risk to human health or the environment from fuel-related contamination resulting from past activities. To evaluate alternatives, results from past sampling events have been summarized and are compared to cleanup levels derived by the Metlakatla Indian Community (MIC). In addition, past sampling results are also compared to risk-based preliminary remediation goals (PRGs) developed by U.S. Environmental Protection Agency (EPA), Region 9, to evaluate the level of effort required to reduce site risk, as opposed to the level of effort required to comply with MIC cleanup levels.

The alternatives identified in this document are considered preliminary and will be used for planning purposes and to help focus future data collection efforts. Results from future data collection efforts will be used to further refine the remedial approach of the Main Dock Tank Farm; therefore, this document should be considered a 'living document" that can be easily modified to incorporate new data as they become available.

This effort is being conducted for the Federal Aviation Administration (FAA) under the U.S. Army Engineer District, Alaska (USAED) Total Environmental Restoration Contract (TERC), Contract Number DACA-85-95-D-0018, Task Order Number 14.

1.1 SITE DESCRIPTION AND HISTORY

The Main Dock Tank Farm (also known as Site 42 in the Coordinated Comprehensive Cleanup Plan) lies adjacent to Tamgas Harbor on the east side of the Metlakatla Peninsula of Annette Island, Alaska. Annette Island lies approximately 900 miles southeast of Anchorage, Alaska, and approximately 15 miles south of Ketchikan, Alaska. Figure 1-1 shows the location of the Main Dock Tank Farm.

The Main Dock Tank Farm was constructed in the early 1940s to store and route fuel to a variety of above-ground storage tanks (ASTs) in support of airfield operations for WWII;

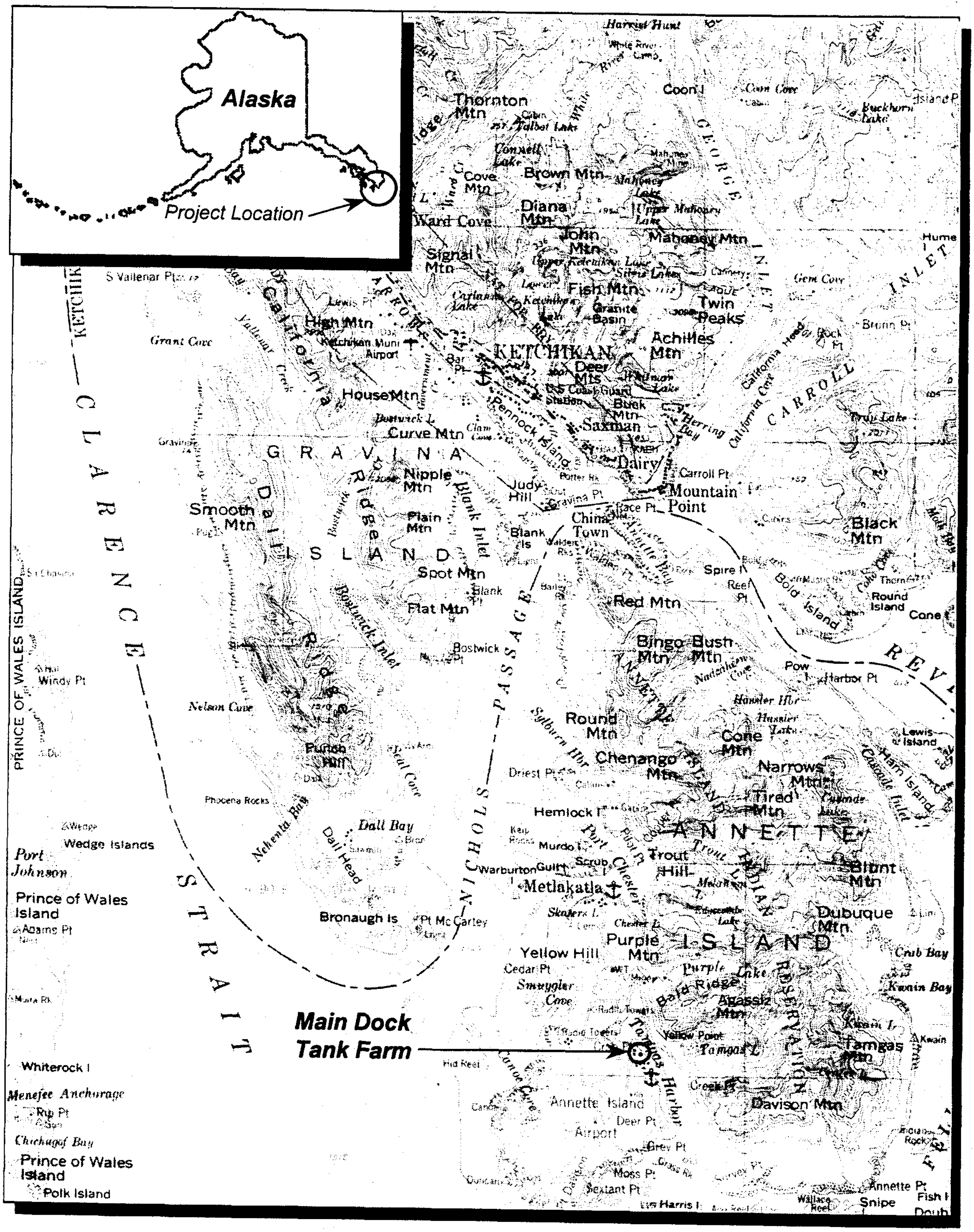

Figure 1-1 Location of the Main Dock Tank Farm

operation of the tank farm ceased in 1977. During that time, a variety of parties either owned or operated the tank farm including the U.S. Army, Standard Oil, the MIC, and the Civil Aeronautics Administration (CAA), predecessor to the FAA. During its operational period, the tank farm throughput ranged from approximately 500,000 to 1,500,000 gallons per year. Fuel was delivered to the main dock from ocean-going vessels, and the fuel was then routed to bulk storage tanks.

A detailed discussion of the Annette Island Airfield history can be found in the documents cited in the references section of this report.

1.2 GEOLOGY AND HYDROGEOLOGY

The Tamgas Harbor area of Annette Island consists of marine sediments overlying fractured bedrock. Based on a review of soil boring logs collected in the general vicinity of the tank farm area, a clay layer is believed to be prominent across the site at approximately 10 feet below ground surface (bgs). Weathered bedrock is believed to be the primary source for the overlying native soils and sediments. Vegetation in the area is primarily marsh grasses and scrub, which is believed to have formed a thick organic mat overlying primarily sandy soils. Precipitation is the primary controlling factor in the amount and availability of surface water in the area. Average annual rainfall is 110 inches per year, with precipitation occurring on an average of 225 days. Surface water occurs in one of four forms: ponded water above surface soils and vegetation, drainages, seeps (evident along the beach at low tide), and the adjacent ocean water body. Two primary drainages exist at the site; one is a seasonal-flowing stream, and the other is a man-made drainage ditch.

Groundwater is believed to occur throughout the area in the unconsolidated surface material overlying bedrock and within fractured and weathered bedrock layers. Depth to groundwater in the vicinity of the Main Dock Tank Farm varies from 1 to 5 feet below ground surface, with the depth believed to be decreasing towards Tamgas Harbor. Regional groundwater flow is towards Tamgas Harbor. Because surface land features on the Metlakatla Peninsula are relatively flat, the groundwater gradient is assumed to be approximately 5 to 10 feet per mile. Groundwater is believed to be influenced by the tides in the Tamgas Harbor, which have a range of approximately 22 feet. Groundwater elevation and salinity are assumed to fluctuate between high and low tides. Saltwater infiltration is known to occur at distances significantly inland, as a water supply well drilled in 1964 from an elevation of 114 feet above sea level was abandoned due to saline intrusion during well testing. Aquifer productivity at depth is also generally poor, with the capacity in the deep wells drilled ranging from less than 0.5 to 10 gallons per minute. As a result, surface water reservoirs are used for drinking water.

1.3 POTENTIAL SOURCE AREAS

Sources of fuel-related compounds in soil and groundwater likely originated from past tank farm operation. Review of historical information and interviews with personnel familiar with the site and its history have resulted in the identification of six release mechanisms which may have contributed to the contamination at the Main Dock Tank Farm, and are as follows:

- Tank overflows during filling;
- Tank overflows due to thermal expansion of fuels as a result of warming to ambient temperatures during summer months;
- Accidental pipeline breaks;
- Incidental pipe and tank leakage;
- Incidental fuel spillage during facility repairs or modifications;
- Routine draining of condensate water forming in the tanks; and
- Routine tank cleaning.

To simplify remedial efforts, Site 42 has been divided into the nine following potential source areas. Each area represents a separate fuel facility or area of potential contaminant impact. The nine potential source areas are shown in Figure 1-2, and include the following:

- Site 42A – Standard Oil Tank Farm;
- Site 42B – North Tank Farm Beach;
- Site 42C – South Tank Farm Beach;
- Site 42D – North Army Beach Tanks;
- Site 42E – South Army Beach Tanks;
- Site 42F – Standard Oil Tank Farm Building;
- Site 42G – Standard Oil Settling AST;

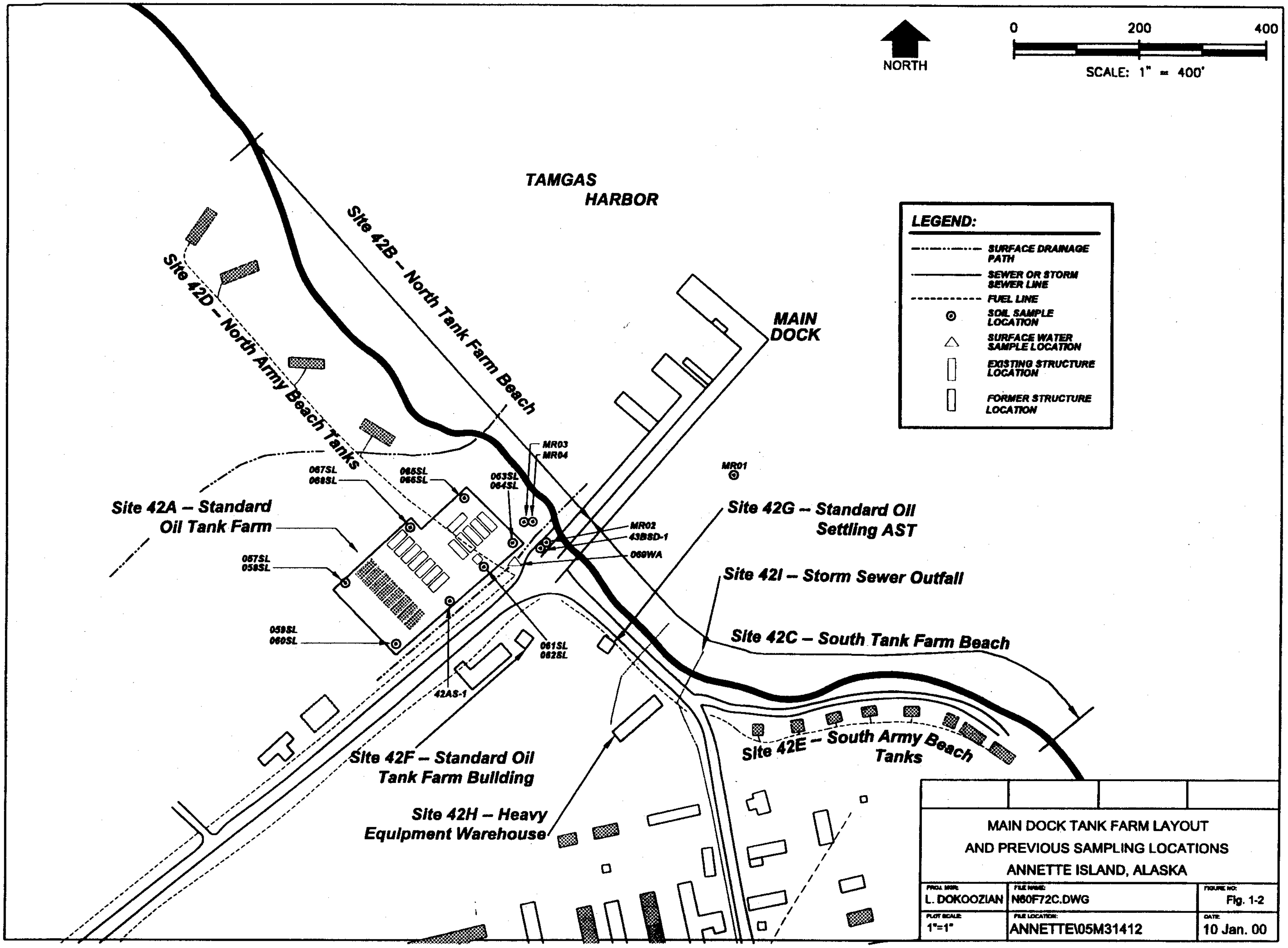
NORTH
0
200
400
SCALE: 1" = 400'
TAMGAS
HARBOR
LEGEND:
SURFACE DRAINAGE PATH
SEWER OR STORM SEWER LINE
FUEL LINE
SOIL SAMPLE LOCATION
SURFACE WATER SAMPLE LOCATION
EXISTING STRUCTURE LOCATION
FORMER STRUCTURE LOCATION
MAIN DOCK
Site 42B – North Tank Farm Beach
Site 42D – North Army Beach Tanks
Site 42A – Standard Oil Tank Farm
MR03
MR04
MR01
MR02
43BSD-1
069WA
067SL
068SL
065SL
066SL
063SL
064SL
057SL
058SL
059SL
060SL
061SL
062SL
42AS-1
Site 42G – Standard Oil Settling AST
Site 42I – Storm Sewer Outfall
Site 42C – South Tank Farm Beach
Site 42E – South Army Beach Tanks
Site 42F – Standard Oil Tank Farm Building
Site 42H – Heavy Equipment Warehouse
MAIN DOCK TANK FARM LAYOUT
AND PREVIOUS SAMPLING LOCATIONS
ANNETTE ISLAND, ALASKA
PROJ. MGR:
L. DOKOOZIAN
FILE NAME:
N60F72C.DWG
FIGURE NO:
Fig. 1-2
PLOT SCALE:
1"=1"
FILE LOCATION:
ANNETTE\05M31412
DATE:
10 Jan. 00

Table 1-1
Main Dock Tank Farm Site Descriptions

Site Number	Physical Characteristics	Site Characteristics

Site 42A – Standard Oil Tank Farm	• The Standard Oil Tank Farm consists of two adjacent areas. One area is approximately 200 feet by 200 feet in areal dimension; the second area is approximately 100 feet by 100 feet
	• Main features are as follows:
	  • One tanker truck loading dock;
	  • Seven 50,000-gallon ASTs;
	  • Two 25,000-gallon ASTs;
	  • One 12,000-gallon AST;
	  • Three 10,000-gallon ASTs; and
	  • Eight 50,000-gallon ASTs (removed in the late 1980s).
	• The tanks were constructed on gravel pads approximately 3 feet thick, which were placed over the existing vegetative mat
	• Approximately 6 inches of standing water is generally observed in one area of the tank farm; this water reportedly drains to Tamgas Harbor via a man-made drainage adjacent to an existing roadway
	• Depth to groundwater is believed to be 3 to 5 feet below the top of the gravel pad
		• Samples were collected from the Standard Oil Tank Farm during the following previous investigations:
		  • 13 soil samples and 1 surface water sample (USAED 1989); and
		  • 2 soil samples (MIC 1998).
		• Comparison of soil analytical data to MIC cleanup levels indicate that TPH, benzene, and isomers of dichlorobenzene are the primary remedial drivers; metals (particularly lead) do not appear to exist at elevated concentrations
		• Soil staining is wide spread, and the soils exhibit a strong petroleum odor
		• Standing water in the tank farm area was noted to have a surface sheen; however, no constituents were detected in a surface water sample collected from a drainage ditch exiting the tank farm area
		• Volume of potentially impacted soil is estimated at 300 feet by 300 feet and an average depth of 4 feet
		• One-third of this volume is assumed to require remediation to reduce site risk to industrial standards (roughly 4,400 cubic yards)
		• Two-thirds of this volume is assumed to require remediation to comply with MIC cleanup levels (roughly 8,900 cubic yards)

Site 42B – North Tank Farm Beach	• Consists of approximately 1,000 feet of beach extending north from the Main Dock, and includes contaminated sediments that may extend into Tamgas Harbor (extent undefined) • At low tide, the distance from the high tide mark and low tide water level is approximately 300 feet • At low tide, the harbor water depth is approximately 30 feet at the end of the dock • Depth to groundwater is approximately 1 foot bgs along the beach, with apparent groundwater seeps emanating frequently during low tides • The beach material is a well graded beach sand with bedrock outcrops – the material is believed to maintain its gradation in the harbor • The beach front is bordered by large (approximate 10 ft diameter trunks) Cedar trees – community preference is to retain the trees	• Based on visual observation, beach sands are stained black from the natural attenuation of petroleum product and exhibit a sulfur odor. Mussels and bedrock outcrops are also stained black • Two samples were collected from the organic mat adjacent to the north beach (USAED 1999) – Diesel-range organic concentrations exceed MIC cleanup levels in one of the two samples; all other constituents analyzed for were reported below MIC cleanup levels • Volume of potentially impacted soil is assumed to be 1,000 feet in length, 300 feet wide, and an average depth of 2 feet -- subtidal contamination is assumed not to exist • One-third of this volume is assumed to require remediation to reduce site risk to industrial standards (roughly 7,500 cubic yards) • Two-thirds of this volume is assumed to require remediation to comply with MIC cleanup levels (roughly 15,000 cubic yards)

Table 1-1
Main Dock Tank Farm Site Descriptions
(continued)

Site Number	Physical Characteristics	Site Characteristics
Site 42C – South Tank Farm Beach	• Consists of approximately 1,000 feet of beach extending south from the Main Dock, and includes contaminated sediments that may extend into Tamgas Harbor • Other features are typical of the north tank farm beach area	• One sediment sample was collected on the south side of the dock near the low tide beach/water interface (USAED 1999) -- no constituents in this sample exceed MIC cleanup levels • Volume of potentially impacted soil is assumed to be 1,000 feet in length, 300 feet wide, and an average depth of 2 feet -- subtidal contamination is assumed to not exist • One-third of this volume is assumed to require remediation to reduce site risk to industrial standards (roughly 7,500 cubic yards) • Two-thirds of this volume is assumed to require remediation to comply with MIC cleanup levels (roughly 15,000 cubic yards)
Site 42D – North Army Beach Tanks	• Former location of four 20,000-gallon ASTs • The tanks were moved in 1948 to the Standard Oil Tank Farm • The ASTs were built upon timber cribbing or platforms, which was laid directly upon existing ground surface (organic mat with speculated sandy material beneath) • Depth to groundwater is believed to be approximately 1 to 2 feet bgs • A seasonal stream runs behind the former tanks, with a flow estimated at 2 gallons per minute (gpm) to nearly dry	• No formal investigations have been conducted at this area • Potential contaminants include fuel-related compounds • Volume of potential impact is assumed to be 50 feet by 50 feet and an average depth of 1 foot at each of four AST locations • One-third of this volume is assumed to require remediation to reduce site risk to industrial standards (roughly 125 cubic yards) • Two-thirds of this volume is assumed to require remediation to comply with MIC cleanup levels (roughly 250 cubic yards)
Site 42E – South Army Beach Tanks	• Former location of six 10,000-gallon ASTs and two 25,000-gallon ASTs • The tanks were moved in 1948 to the Standard Oil Tank Farm • The ASTs were built upon timber cribbing, which was laid directly upon existing ground surface (organic mat with speculated sandy material beneath) • Depth to groundwater is believed to be approximately 1 to 2 feet bgs	• No formal investigations have been conducted at this area • Potential contaminants include fuel-related compounds • Volume of potential impact is assumed to be 50 feet by 50 feet and an average depth of 1 foot at each of eight AST locations • One-third of this volume is assumed to require remediation to reduce site risk to industrial standards (roughly 250 cubic yards) • Two-thirds of this volume is assumed to require remediation to comply with MIC cleanup levels (roughly 500 cubic yards)

Table 1-1
Main Dock Tank Farm Site Descriptions
(continued)

Site Number	Physical Characteristics	Site Characteristics
Site 42F – Standard Oil Tank Farm Building (B/217)	• Location of a building used by Standard Oil to store drummed petroleum products • The building was located across the Main Dock Road from the Standard Oil Tank Farm; timber pile remnants remain at the building location • Stream passes near the building; depth to groundwater is believed to be 1 to 2 feet bgs • The ground surface in the immediate building vicinity lies about 3 feet below the surface of an adjacent road • Soil is believed to be an organic mat with possible sandy material beneath • Fuel pipelines pass near the building foot print	• No formal investigations have been conducted at this area • Potential contaminants include fuel-related compounds and solvents • Volume of potentially impacted soil is estimated to be 100 feet by 50 feet and an average depth of 2 feet bgs • One-third of this volume is assumed to require remediation to reduce site risk to industrial standards (roughly 125 cubic yards) • Two-thirds of this volume is assumed to require remediation to comply with MIC cleanup levels (roughly 250 cubic yards)
Site 42G – Standard Oil Settling AST	• Present location of a 7,000-gallon square riveted AST built on timber cribbing; located approximately 150 feet east of the Standard Oil Tank Farm Building (installed in the 1940s) • Used as an oil/water separation tank • Soil is believed to be an organic mat with possible sandy material beneath • Depth to groundwater is believed to be 1 to 2 feet bgs	• No formal investigations have been conducted at this area • Potential contaminants include fuel-related compounds • Volume of potentially impacted soil is estimated to be 50 feet by 50 feet and an average depth of 2 feet bgs • Volume of potential impact is assumed to be 50 feet by 50 feet and an average depth of 1 foot at each of four AST locations • One-third of this volume is assumed to require remediation to reduce site risk to industrial standards (roughly 60 cubic yards) • Two-thirds of this volume is assumed to require remediation to comply with MIC cleanup levels (roughly 120 cubic yards)
Site 42H – Heavy Equipment Warehouse	• Located approximately 300 feet south of the Tank Farm Building • Use of this facility is not certain, but was likely used to maintain heavy equipment associated with airport operations • Historic utility maps show a drain that ran from building to the south beach area, in addition to a septic tank with a discharge line that led to the south beach area	• No formal investigations have been conducted at this area • No soil contamination is assumed to exist at this location
Site 42I – Storm Sewer Outfall	• Located approximately 300 feet south of the Main Dock • Historic utility maps show that this outfall was connected to Building 313, which is believed to have been an automobile repair shop	• No formal investigations have been conducted at this area; however, the outfall area is suspected to be potentially contaminated with solvents and fuel-related compounds (based on soil contamination observed at Building 313) • Area of potential impact is considered part of the Site 42C scope

- Site 42H – Heavy Equipment Warehouse; and
- Site 42I – Storm Sewer Outfall.

Environmental media potentially impacted at these areas include soil, surface drainage sediments, beach sediments, surface water, and groundwater. Table 1-1 summarizes the physical and site characteristics of each area. In addition, assumptions are provided in this table regarding areas of potentially impacted soil and volumes of soil that may require remediation.

1.4 SUMMARY OF PREVIOUS INVESTIGATIONS

The following three separate investigative efforts have been conducted at the Main Dock Tank Farm:

- USAED 1989 (conducted by Ecology and Environment);
- MIC 1998 (conducted by Ridolfi Engineers, Inc.); and
- USAED 1999 (conducted by DOWL/Ogden Joint Venture).

The first two investigations focused on the Standard Oil Tank Farm Area. The investigation conducted in 1999 focused sampling efforts near the Main Dock. In addition, the U.S. Coast Guard (USCG) conducted a limited removal action in April 1999. This action included the removal of above-ground fuel piping from the main dock area and the excavation of approximately 30 cubic yards of soil contaminated with fuel-related compounds. Soil excavation was conducted where soil staining and surface water sheens were identified at an area with water upwelling from the road leading to the Main Dock Tank Farm (i.e., commonly known as the "roadboil"). Sampling results were not available at the time of preparing this report; however, no additional contaminated soil is anticipated at this location.

Figure 1-2 shows all previous investigation sampling locations. Table 1-2 compares the sampling results to MIC cleanup levels and EPA Region 9 PRGs.

On the basis of previous investigation results (Table 1-2), total petroleum hydrocarbons (TPH), benzene (i.e., fuel-related compounds), and isomers of dichlorobenzene are considered to be the primary remedial drivers for the Main Dock Tank Farm. Metals, including lead, do not appear to

Table 1-2
Summary of Previous Investigation Sampling Results
Main Dock Tank Farm
Annette Island, Alaska

Sample Number	Sample Depth (ft bgs)	GRO*	DRO*	RRO*	Benzene	Toluene	Ethyl-benzene	Xylene	Chlorobenzene	1,2-DCB	1,4-DCB	Chloroform	4,4'-DDD	4,4'-DDT	PCA**	1,1-DCE	Lead
EPA Region 9 PRG, Industrial, Except as Noted (mg/kg)		260	230	8300	1.5	520	230	210	540	370	8.1	0.52	17	12	0.9	0.12	1,000
MIC Cleanup Level (mg/kg)		100	200	200	0.1	40	20	20	NL	6	0.7	NL	NL	1.7	NL	NL	200
USAED, 1989																	
057SL (mg/kg)	0.5		**2130*****		ND	0.14	ND	0.69	0.3	2.41	**1.06**	ND	ND	0.05	ND	*0.44*	**235**
058SL (mg/kg)	2.5		**1240***		**0.66**	0.21	1.32	2.94	ND	5.58	**2.69**	ND	ND	ND	ND	*0.53*	148
059SL (mg/kg)	0.5		**727*****		**0.17**	0.31	1.6	5.31	ND	3.28	**2.06**	ND	ND	ND	ND	*0.17*	17.1
060SL (mg/kg)	0.5		**618*****		**0.14**	0.79	1.76	**45.27**	0.57	**28.38**	ND	ND	ND	ND	ND	*1.43*	55.1
061SL (mg/kg)	0.25		**958*****		***2.8***	0.83	1.36	2.6	1.16	2.69	**1.74**	ND	ND	ND	ND	*0.45*	97.9
062SL (mg/kg)	2		**1140*****		***15.37***	ND	2.9	**29.3**	1.15	**27.98**	ND	ND	ND	ND	ND	*0.29*	37.2
063SL (mg/kg)	0.25		**422*****		***3.3***	1.48	3.45	**21.61**	2.49	3.81	**2.96**	ND	ND	ND	ND	*0.18*	167
064SL (mg/kg)	2		**1100*****		***1.62***	0.45	1.06	13.6	0.36	3.42	**4.37**	ND	ND	ND	ND	*0.84*	29
065SL (mg/kg)	0.5		ND***		ND	0.54	0.97	0.38	ND	2.13	**1.4**	ND	ND	ND	ND	*0.33*	9.2
066SL (mg/kg)	2		ND***		ND	ND	ND	0.11	ND	0.22	ND	ND	ND	ND	ND	*0.29*	5.3
067SL (mg/kg)	0.5		**285*****		ND	0.33	ND	0.17	ND	ND	ND	0.16	0.1	0.22	0.14	*0.22*	75.6
068SL (mg/kg)	2		ND***		ND	0.18	0.25	2.55	ND	ND	ND	0.16	ND	ND	0.13	*0.2*	ND
069WA -- surface water (mg/l)	Water Sample		ND***		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MIC, 1998																	
42AS-1(mg/kg)	0.5	8.6	***19,000***	**410**	0.09	0.09	0.09	0.09	ND (0.041)	NA	NA	NA	NA	NA	NA	NA	***1,110***
43BSD-1(mg/kg)	0.5	5	9.8	65	ND (0.041)	ND (0.041)	ND (0.041)	ND (0.041)	ND (0.041)	ND (0.041)	ND (0.041)	ND (0.041)	ND (0.0038)	ND (0.0038)	ND (0.041)	ND (0.041)	6
USAED, 1999																	
MR01 -- marine sediment (mg/kg)	0.5	1.3	19	51	ND (0.028)	ND (0.028)	ND (0.028)	ND (0.028)	NA	NA	NA	NA	NA	NA	NA	NA	29
MR02 (mg/kg)	0.5	ND (0.56)	ND (11)	ND (23)	ND (0.014)	ND (0.014)	ND (0.014)	ND (0.014)	NA	NA	NA	NA	NA	NA	NA	NA	4.4
MR03 (mg/kg)	0.5	15	***350***	***770***	ND (0.29)	ND (0.29)	ND (0.29)	ND (0.29)	NA	NA	NA	NA	NA	NA	NA	NA	61
MR04 (mg/kg)	0.5	1.9	140	91	ND (0.046)	ND (0.046)	ND (0.046)	ND (0.046)	NA	NA	NA	NA	NA	NA	NA	NA	42

Notes: * Value based on Alaska Department of Environmental Conservation standard
** 1,1,2,2-tetrachloroethane used as a surrogate
*** Result reported as TPH (total); no speciation between gasoline, diesel, or residual fractions conducted
All results are for soil samples unless otherwise noted
14 Result exceeds MIC cleanup level
14 Result exceeds risk-based concentration

NA = Constituent not analyzed during previous investigation
ND = Constituent not detected during previous investigation (method detection limit provided in parenthesis when available)
NL = Constituent not listed in cited regulation
GRO = Gasoline-range organics
DRO = Diesel-range organics
RRO = Residual-range organics
1,2-DCB = 1,2-Dichlorobenzene
1,4-DCB = 1,4-Dichlorobenzene
PCA = Tetrachloroethane
1,1-DCE = Dichloroethylene

exist at elevated levels. This is consistent with the results of a draft human health and ecological risk assessment conducted for the Main Dock Tank Farm (FAA, 1996). However, data are limited; no groundwater samples or subsurface beach sediment samples were collected during previous investigations. Soil data are also limited, as some potential release locations have not been sampled at the time of preparing this report. Results of future site investigations may require the addition of other constituents as remedial drivers.

In light of these data gaps, the FAA is currently planning a remedial investigation for the summer of 2000; the Main Dock Tank Farm is included in the scope of that investigation.

For the purposes of selecting and implementing a remedial alternative at the Main Dock Tank Farm, the following general data needs have been identified:

- Areal extent and depth of fuel-related compounds (including the percentage of light- and heavy-end fractions remaining on site) in soil, beach sediment, groundwater, and surface water exceeding risk-based and MIC-mandated criteria;
- Confirm the presence or absence of other compounds in soil, beach sediment, groundwater, and surface water (e.g., metals, pesticides, and solvents) and, if present, determine areal extent and depth of such compounds in soil exceeding risk-based and MIC-mandated criteria;
- Establish ambient inorganic background thresholds for soil, beach sediment, surface water, and groundwater;
- Confirm the presence or absence of indigenous oil-consuming microbes in soil, beach sediment, and groundwater to help support the development of bioremediation and natural attenuation alternatives;
- Determine soil and beach sediment geotechnical properties, including gradation, moisture content, dewatering potential, and organic carbon content;
- Establish site lithology/stratigraphy including the depth to bedrock and the presence, depth, and thickness of a clay layer believed to be present across the site;
- Confirm the groundwater flow direction, gradient, depth, and probable yield (i.e., subsurface hydrogeology);
- Determine potential offsite migration pathways for contaminated surface water and groundwater; and
- Establish future land use for the site and site closure criteria.

These data gaps have been further expanded in Section 3 on an alternative-specific basis.

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2.0 REMEDIAL APPROACH

Prior to the identification of specific remedial alternatives, an overall remedial approach for the Main Dock Tank Farm was developed. The remedial approach includes the definition of program goals, remedial action objectives, remedial strategies, and general data gaps, as well as other site-specific issues. Each of these factors is considered in the identification of remedial options. Remedial action objectives define the parameters against which to measure the effectiveness of a remedial alternative. Remedial strategies outline measures that can be taken to streamline the remedial process, as well as ways to improve the efficiency of a given remedial option.

As data needs are filled, remedial alternatives may need to be reconsidered. Because the collection of additional data is anticipated at the Main Dock Tank Farm before a remedy is selected, the remedial approach may therefore require modification. As such, the remedial approach for the Main Dock Tank Farm, as defined in Table 2-1, should be routinely updated throughout the remedial process.

Remedial alternatives were developed based on the overall program goal of protecting human health and the environment at the Main Dock Tank Farm. Remedial action objectives (RAOs) developed to support this goal are as follows:

- Reduce potential risk through removal or containment; and
- Comply with MIC cleanup levels.

These RAOs apply to soil, freshwater sediment, beach sediment, surface water, and groundwater. The development of remedial strategies, data needs, and general considerations for the future evaluation of remedial alternatives once additional data are obtained are presented and discussed in Table 2-1.

Table 2-1
Remedial Action Approach

Program Goal	Remedial Action Objectives	Remedial Strategies	Considerations
Protect human health and the environment from contaminants at the Main Dock Tank Farm	1. Reduce potential risk through removal or containment 2. Comply with cleanup levels established by the Metlakatla Indian Community	***Soil and Sediment*** • Address soil contamination on a site-by-site basis to allow incremental project funding, maximizing the capture of funding • Develop alternatives for freshwater sediment in conjunction with soil alternatives • Develop beach sediment alternatives separately from soil alternatives • Identify future land uses and select remedial alternatives consistent with those uses • For ex situ technologies, treat soil in bulk quantities • Continue to evaluate innovative technologies to increase treatment efficiency and lower remediation costs • Incorporate flexibility into remedial alternatives to allow simultaneous remediation and site characterization ***Surface Water and Groundwater*** • Address groundwater contamination 'globally' to allow efficient mitigation of potential offsite risks • Remediate groundwater 'hot spots' simultaneously with areas requiring soil remediation • Identify future land uses and select remedial alternatives consistent with those uses	• Funding limitations • Additional site characterization is required, which may affect preliminary recommendations of remedial alternatives • MIC acceptance of remedial alternatives such as capping, monitored natural attenuation, etc. • MIC cleanup policies and the application of State and Federal regulations are under development • Soil containing metals at elevated concentrations may require separate or additional treatment • Extent of brackish groundwater

3.0 REMEDIAL ALTERNATIVE SELECTION

Remedial alternatives were developed using a process similar to that used for Superfund sites. This process includes the identification and screening of broad remedial categories, known as general response actions (e.g., the excavation of soil), followed by the identification of increasingly more site-specific remedial technologies through continued screening. The overall process used to develop remedial alternatives for the Main Dock Tank Farm is summarized in the following bullets:

- Determine general response actions that appear applicable to the Main Dock Tank Farm based on existing data;
- Eliminate from further consideration those general response actions that are not relevant or applicable;
- Compile a list of remedial technologies consistent with the retained general response actions;
- Screen the proposed remedial technologies based on a set of simplified criteria;
- Combine the retained technologies to form remedial alternatives;
- Qualitatively evaluate the advantages and disadvantages of each remedial alternative in terms of the screening criteria; and
- Conduct a comparative analysis of the selected remedial alternatives.

The remainder of this section describes the results of this process.

3.1 SCREENING OF GENERAL RESPONSE ACTIONS

General response actions are fundamental media-specific remedial approaches that are used to satisfy the remedial action objectives. General response actions that address fuel-related compounds for soil/freshwater sediment, beach sediment, and water (i.e., surface water and groundwater) are presented in Table 3-1.

General response actions and representative treatment methods for each medium are combined to form remedial alternatives. More than one general response action is typically applied to each medium. For example, institutional controls are often combined with treatment methods to form a comprehensive remedial action alternative.

Table 3-1
General Response Actions

General Response Action	Description
Soil, Freshwater Sediment, and Beach Sediment	
Institutional Controls	• A remedial approach that mitigates exposure to contaminated soil but provides no containment or treatment. Monitoring is often a required component ↳ Examples include access restrictions and monitored natural attenuation
Containment	• A remedial approach that limits the mobility of contaminants in soil but does not remove or provide in situ destruction of contaminants ↳ Examples include capping, solidification/stabilization, and encapsulation
Excavation/Disposal	• A remedial approach that involves excavation and disposal of contaminated soil with no treatment • Because this response option does not provide treatment, acceptable disposal options are usually limited to offsite facilities
Excavation/Treatment/ Disposal	• Any approach that excavates and treats soil prior to disposal ↳ Examples include incineration, thermal desorption, landfarming, and composting
In situ Treatment	• Any approach that treats contaminated soil without removing or collecting contaminated media ↳ Examples include bioventing and soil vapor extraction
Surface Water and Groundwater	
Institutional Controls	• A remedial approach that limits and monitors exposure to contaminated water, but provides no containment or treatment ↳ Examples include the maintenance of a fenced facility, deed restrictions, water use restrictions, and monitored natural attenuation. Monitoring is often a required component
Containment	• A remedial approach that limits the mobility of contaminants in groundwater, but does not provide in situ destruction of contaminants ↳ Pump and treat is the technology generally used for this purpose
Diversion	• A remedial approach that diverts contaminated water from uncontaminated media, or diverts uncontaminated water away from contaminated media to reduce the volume of media requiring treatment ↳ Examples include sheet pile walls, slurry walls, french drains, and intercept trenches
Collection/Discharge	• A remedial approach that extracts and discharges water without treatment. • Because no treatment is involved, potential risk from exposure is not eliminated and acceptable discharge options are usually limited ↳ Examples include horizontal extraction wells, vertical extraction wells, and intercept trenches
Collection/Treatment/ Discharge	• A remedial approach that collects and provides treatment of water prior to discharge ↳ Examples of treatment technologies include carbon adsorption and constructed wetlands
In situ Treatment	• A remedial approach which provides treatment of contaminated groundwater without collecting or discharging groundwater ↳ Examples include air sparging and oxygen-releasing compounds

General response actions were screened separately for soil and beach sediment because remedial technologies differ significantly for these media; this was primarily due to sediment excavation and dewatering requirements. General response actions for surface water and groundwater were screened as one medium as applicable remedial technologies for both media are very similar.

3.1.1 Screening of General Response Actions for Soil

The following general response actions were retained for soil and freshwater sediment after site-specific conditions at the Main Dock Tank Farm were considered:

- Institutional controls; and
- Excavation, treatment, & onsite disposal.

While containment would be effective in achieving the first RAO (risk reduction), it would not make progress toward meeting the second RAO (compliance with MIC cleanup levels). This is because containment would not reduce the volume, concentration, or toxicity of constituents present at the site. Therefore, containment was eliminated from further consideration.

In situ treatment was not retained because of relatively shallow groundwater levels across the site (one to five feet below ground surface). This would limit the cost-effectiveness of in situ technologies due to influence zones being limited by a relatively thin vadose zone, requiring a large number of treatment wells to cover a given area.

Excavation and onsite disposal without treatment was not retained; it is not likely that a suitable disposal location for untreated soil could be permitted, constructed, and properly maintained on Annette Island. Furthermore, progress toward meeting the second RAO (compliance with MIC cleanup levels) would not be achieved.

Excavation and offsite disposal does not appear to be an appropriate option for Site 42 from an economic perspective, since existing data indicates that site contamination can be treated using onsite techniques. However, the potential exists for encountering constituents during future investigations that are difficult to treat onsite. Such constituents include lead and pesticides, which were detected during past investigations but not at elevated levels.

3.1.2 Screening of General Response Actions for Beach Sediment

The following general response actions were retained for beach sediment after site-specific conditions at the Main Dock Tank Farm were considered:

- Institutional controls;
- In situ treatment; and
- Excavation, treatment, & onsite disposal.

Containment of potentially contaminated beach sediments was not retained as a general response action, as containment options are not likely reliable in the long-term and would probably disrupt the existing habitat.

The remaining general response actions were not retained for further analysis for the same reasons they were not retained for application to contaminated soil.

3.1.3 Screening of General Response Actions for Surface Water and Groundwater

The following general response actions were retained for water after site-specific conditions at the Main Dock Tank Farm were considered:

- Institutional controls;
- Collection, treatment, & discharge;
- Diversion; and
- In situ treatment.

Containment of water was eliminated from further analysis because prevention of all offsite migration of contaminated groundwater is considered technically impracticable. This is due to complex hydrologic site features, such as the presence of fractured bedrock believed to be underlying the Annette Island Peninsula. However, collection of contaminated water or free product could be used to limit the amount of potential contaminant migration.

Limited channeling or diversion of surface water and shallow groundwater may be possible and was considered for further analysis. Although prevention of all offsite migration of contaminated groundwater may be impracticable, minimizing the contact between water and soil containing fuel-related compounds would reduce the magnitude of surface water or groundwater contamination.

Collection and discharge of water without treatment was eliminated from further analysis. This is because acceptable discharge options for large quantities of untreated groundwater likely do not exist at this site, as nearby water bodies are considered environmentally sensitive.

3.2 REMEDIAL TECHNOLOGY SCREENING

Based on the retained general response actions, a list of remedial technologies was prepared. Remedial technologies, such as composting, are types of media-specific actions associated with each general response action that are considered to be potentially effective for the Main Dock Tank Farm. Ultimately, those remedial technologies that are retained as a result of the screening process are used to formulate a list of viable remedial alternatives.

To refine the list of potential options, each remedial technology was screened against five simplified criteria. These criteria were developed to help identify which technologies would best satisfy the overall remedial approach for the site (as discussed in Section 2). These criteria are as follows:

- **Technically Implementable** – the remedial technology could be constructed given site-specific conditions and would be effective at a given potential source area;
- **Field Proven in Alaska** – the remedial technology has been proven under the unique conditions encountered in Alaska;
- **Satisfies RAOs** – the remedial technology would satisfy the RAOs when implementation is complete. In addition, if the remedial alternative satisfies the first RAO (i.e., risk reduction), then the alternative must make progress toward meeting the second RAO (i.e., compliance with MIC cleanup levels);
- **Cost Effective** – the remedial technology is more cost-effective than other remedial technologies for a given general response action; and
- **Community Preference** – there is an anticipated community preference for a given remedial technology, such as the potential for local employment through system operation and maintenance (O&M). Community preference is also anticipated for those remedial alternatives that would result in minimal disruption of the natural environment.

Table 3-2 presents the results of the screening process; bold text indicates those remedial technologies that were retained to form remedial alternatives.

Table 3-2
Remedial Technology Screening Results

General Response Action	Remedial Technologies	Screening Criteria: Technically Implementable	Field Proven in Alaska	Cost-Effective	Satisfies RAOs	Community Preference	Remarks
Soil							
Institutional Controls	• **Access Restrictions** • **Monitored Natural Attenuation**	✓	✓	✓	✓	*	• **Retained for further analysis**
Excavation, Treatment, & Disposal	*Excavation*						
	• **Backhoe**	✓	✓	✓	✓	*	• **Retained for further analysis**
	• Dozer		✓		✓	*	• Cost effective only in very large excavations
	Treatment						
	• **Thermal Desorption**	✓	✓		✓	*	• **Retained for further analysis**
	• Hot Air Vapor Extraction (HAVE)	✓	✓	✓		*	• Not effective on heavy end hydrocarbons
	• Bioslurry	✓		✓	✓	*	• Not effective for fine soil types
	• Soil Washing	✓			✓	*	• Not widely available commercially
	• **Composting**	✓	✓	✓	✓	*	• **Retained for further analysis**
	• **Landfarming**	✓	✓		✓	*	• **Retained for further analysis**
	Disposal						
	• **Backfill Excavation**	✓	✓	✓	✓	*	• **Retained for further analysis**
	• **Onsite disposal at designated locations**	✓	✓	✓	✓	*	• **Retained for further analysis**
Beach Sediment							
Institutional Controls	• **Access Restrictions** • **Monitored Natural Attenuation**	✓	✓	✓	✓	*	• **Retained for further analysis**
In situ Treatment	• In situ Aeration	✓		✓		*	• Not field proven in Alaska
	• **Landfarming**	✓		✓	✓	*	• **Retained for further analysis, may require containment as a component**

Table 3-2
Remedial Technology Screening Results
(continued)

General Response Action	Remedial Technologies	Screening Criteria: Technically Implementable	Field Proven in Alaska	Cost-Effective	Satisfies RAOs	Community Preference	Remarks
Excavation, Treatment, & Disposal	*Excavation*						
	• **Mechanical dredging (backhoe, dragline, clam shovel)**	✓	✓	✓	✓	*	• **Retained for further analysis** • **Effectiveness may be limited by bedrock outcrops present along the beach**
	• Hydraulic Dredging	✓	✓	✓	✓	*	• Extensive dewatering requirements – would be desirable for subtidal excavations if significant bedrock outcrops exist
	Treatment						
	• Active Dewatering (e.g., Filter Press)	✓	✓		✓	*	• Not cost effective
	• **Passive Dewatering (Soil Holding Cell, Settling Basins, etc)**	✓	✓	✓	✓	*	• **Passive dewatering in dewatering cell retained for further analysis – assumes sediments do not contain large quantities of fines (passing the #200 sieve)**
	• Bioslurry	✓		✓	✓	*	• Not field proven in Alaska or widely available commercially • Would work well for non-dewatered sediment
	• Composting	✓	✓		✓	*	• Large excavation costs
	• Landfarming	✓	✓		✓	*	• Can be conducted in situ
	• **Thermal treatment**	✓	✓	✓	✓	*	• **Retained for further analysis**
	• Soil Washing	✓			✓	*	• Not field proven in Alaska or widely available commercially • Would work well for non-dewatered sediment
	Disposal						
	• Backfill harbor	✓				*	• Could cause significant amounts of turbidity in Tamgas Harbor
	• **Onsite disposal**	✓	✓	✓	✓	*	• Retained for further analysis
Water							
Institutional Controls	• **Access restrictions** • **Water use restrictions** • **Monitored natural attenuation**	✓	✓	✓	✓	*	• **Retained for further analysis**

Table 3-2
Remedial Technology Screening Results
(continued)

General Response Action	Remedial Technologies	Screening Criteria: Technically Implementable	Field Proven in Alaska	Cost-Effective	Satisfies RAOs	Community Preference	Remarks
Diversion	• Slurry Walls		✓	✓	✓	*	• May be difficult to implement giving shallow groundwater depth and could potentially compromise the clay layer believed to be present across the site
	• **Sheet Pile**	✓	✓		✓	*	• **Retained for further analysis** • **Can be applied to surface water as well**
	• French drain (surface water only)		✓	✓	✓	*	• Surface water collection/treatment not necessary based on existing data
Collection, Treatment, & Discharge	***Collection***						
	• **Interceptor trench**	✓	✓	✓	✓	*	• **Retained for further analysis**
	• Vertical extraction wells		✓		✓	*	• Presence of shallow groundwater would require many wells to achieve capture
	• Horizontal extraction wells	✓	✓		✓	*	• Less cost effective than intercept trench
	Treatment						
	• **Carbon adsorption**	✓	✓		✓	*	• **Retained for further analysis**
	• **Constructed wetlands**	✓	✓		✓	*	• **Retained for further analysis**
	• UV Oxidation	✓			✓	*	• Higher O&M costs as compared to wetlands or carbon adsorption
	Discharge						
	• Land surface			✓	✓	*	• Saturated ground conditions would limit infiltration and increase likelihood of discharge to surface water bodies
	• Infiltration gallery			✓	✓	*	• Saturated ground conditions would limit infiltration and increase likelihood of discharge to surface water bodies
	• Surface water	✓	✓	✓	✓	*	• Permitting requirements uncertain
	• **Underground injection**	✓	✓	✓	✓	*	• **Retained for further analysis**
In situ Treatment	• **Oxygen-Releasing Compounds**	✓	✓		✓	*	• **Retained for further analysis**
	• Air Sparging	✓		✓	✓	*	• Studies have shown that this technology is not as effective as oxygen releasing compounds

Notes:
Bold text indicates those remedial technologies that were retained to form remedial alternatives
* Community preference is evaluated only for those technologies that were retained for further analysis – see Section 3

3.3 EVALUATION OF PRELIMINARY REMEDIAL ALTERNATIVES

Those remedial technologies that were retained during the screening process were assembled to form viable remedial alternatives. These remedial alternatives best satisfy the remedial approach and strategies for the Main Dock Tank Farm, and are presented in Table 3-3.

Table 3-3
Main Dock Tank Farm Preliminary Remedial Alternatives

Soil	Beach Sediment	Water
1. Access restrictions with monitored natural attenuation 2. Excavation, thermal desorption, backfill excavation 3. Excavation, composting, onsite disposal 4. Excavation, landfarming, onsite disposal	1. Access restrictions with monitored natural attenuation 2. Beach excavation, sediment dewatering, sediment treatment, water treatment 3. In situ landfarming	1. Access restrictions with monitored natural attenuation 2. Interception trench, constructed wetlands treatment, underground injection 3. Interception trench, carbon treatment, underground injection 4. Surface water and shallow groundwater diversion 5. In situ treatment using oxygen-releasing compounds

In this section, each remedial alternative is first described in detail, followed by an explanation of how the remedial alternative would be applied at the Main Dock Tank Farm. Next, the advantages and disadvantages of each remedial alternative are considered in terms of the screening criteria developed in Section 3.2, as well as alternative-specific data needs that might govern remedy selection. Lastly, the estimated cost of each alternative, including capital and O&M costs, are presented based on the level of effort assumed for RAO 1 (risk reduction) and RAO 2 (compliance with MIC cleanup levels).

Costs for each remedial alternative were calculated using the Remedial Action Cost Engineering and Requirements System (RACER)/ENVEST™ cost-estimating model. The Government developed this cost model for the specific purpose of comparing remedial alternatives during the remedy selection process and for programming purposes. Costs are considered to be rough order-of-magnitude, and are accurate to within –30 to +50 percent of the actual costs per EPA guidance (EPA 1988). Based on the assumptions regarding the level of effort for a given remedial alternative, the estimated costs are rounded to the nearest $10,000 to reflect the order-of-magnitude nature of the estimates. Appendix A contains key assumptions used in the cost model, as well as cost estimate backup. In addition, main cost drivers are provided for each media evaluated in the following subsections.

3.3.1 Soil Remedial Alternatives

Soil remedial alternatives consider the scope required to achieve the two RAOs developed in Section 2 of this report. For the purposes of estimating cost, it is assumed that the cost to achieve RAO 1 (risk reduction) would require remediation of 33 percent of the potential impacted soil volume (approximately 5,000 cubic yards). To achieve RAO 2 (compliance with MIC cleanup levels), it is assumed that 67 percent of the potentially impacted soil volume would require remediation (roughly 10,000 cubic yards). These percentages generally correspond with the number of soil sample results that exceed the respective cleanup criteria as presented in Table 1-2.

3.3.1.1 Soil Alternative 1 –Institutional Controls with Monitored Natural Attenuation

Institutional controls (also known as access restrictions) include restrictions such as deed or water rights restrictions, land use restrictions, and land purchase restrictions. Physical controls, such as erecting a perimeter fence to prevent site access, might also be included.

Natural attenuation of petroleum hydrocarbons is a well-documented, cost-effective remedial method, and includes the processes that allow contaminants to be degraded by natural physical, biological, or chemical processes without active treatment. Each process diminishes constituent concentrations and consequently reduces the risk to potential receptors. Compliance with MIC cleanup levels would eventually be reached, but likely in a long period of time. The release of hydrocarbons into soil provides a primary carbon source which bacteria and other microorganisms digest. This process can also be successful for solvents and other types of organic contamination, but is not as favorable for contaminants such as pesticides or metals.

Monitoring to ensure that the alternative remains protective of human health and the environment is an essential part of this remedy. For soil, monitoring would occur through the collection of shallow soil samples (hand auger) collected annually in designated areas of known contamination. The list of sample analytes would typically include those that are used to document and quantify the process of natural attenuation (such as iron and manganese content), as well as those that detect the presence of fuel-related compounds.

The costs associated with this alternative are as follows:

RAO 1

Capital Cost:	**$ 0**
O&M Cost:	**$ 350,000**
Total Cost:	**$ 350,000**

RAO 2

Capital Cost:	**$ 0**
O&M Cost:	**$ 480,000**
Total Cost:	**$ 480,000**

Table 3-4 presents the advantages and disadvantages of this alternative, in addition to those data required for effective implementation.

Table 3-4
Evaluation of Soil Alternative 1 -- Institutional Controls with Monitored Natural Attenuation

Advantages	Disadvantages	Preliminary Data Needs
Technically Implementable		**Contaminant Considerations:** • Types and concentrations of fuel-related contaminants, including the fractions of light- and heavy end hydrocarbons remaining in soil; • Depth profile and distribution of contaminants; • Presence of toxic contaminants (i.e., pesticides and polychlorinated biphenyls [PCBs]); • Presence of volatile organic compound (VOCs); and • Presence of inorganic contaminants (e.g., metals) **Soil and Groundwater Geochemical Considerations:** • Geochemical data to assess the potential for biodegradation of the contaminants **Site/ Media Considerations:** • Lithology and stratigraphic relationships; • Grain-size distribution (sand vs. silt vs. clay); • Flow gradient; • Preferential flow paths; • Interaction between groundwater and surface water; • Temperature, precipitation, wind velocity and direction; • Water availability; • Soil moisture content; • Soil organic matter content; • Soil cation exchange capacity; • Soil nutrient content, pH, and permeability; and • Microorganism populations present at the site, including the presence of indigenous oil-consuming microbes
• Local personnel can be trained to conduct monitoring events • No equipment to maintain • No operation or activity required in winter months • Required services and supplies are readily available	• Sampling equipment and supplies would have to mobilized to the site on a regular basis • Samples would have to be sent offsite for analysis	
Field Proven in Alaska		
• Widely recognized as a viable cleanup alternative in Alaska • Southeast Alaska climate is more favorable as compared to more northern site locations	• None	
Cost Effective		
• Generally considered to be cost-effective • The least expensive alternative	• None	
Satisfies RAOs		
• Permanently reduces contaminant concentrations over time • Access restrictions would mitigate risk to human health during cleanup	• Long time to reach cleanup levels • Risk to some wildlife (such as birds and water fowl) would be difficult to mitigate while RAOs are being met	
Community Preference		
• The potential exists to create a limited number of jobs for local residents • No impact to local flora or fauna	• Access restrictions may be inconvenient to local residents	

3.3.1.2 Soil Alternative 2 – Excavation with Thermal Desorption

This alternative would require the excavation and stockpiling of contaminated soil, thermal treatment of the soil onsite at the Main Dock Tank Farm, and backfilling excavated areas with treated soil. The limits of excavation would be defined using field screening techniques and would be confirmed with standard laboratory analyses. The thermal desorber consists of a rotating drum, which is heated by a burner. Contaminated soil is fed into the unit, where it remains for a given time period; the actual residence time would be determined in the field. During heating, volatile compounds are subsequently released from the soil.

A soil holding cell would be constructed onsite prior to treatment. Soil from multiple areas would be stockpiled and thermally treated as a batch. Depending on the volume of contaminated soil identified, this may require more than one mobilization of the thermal desorption unit. The high water content of some of the low-permeability soils may require an extended treatment duration or a separate dewatering treatment stage.

Air emissions from the thermal desorption unit may have to be treated. The combined concentrations of volatile organic compound (VOCs) detected in the soil (once established) would be used to calculate whether this would be a requirement, based on the tons of VOCs emitted from the treatment system. The federal permitting threshold is 25 tons of total VOCs per year; treatment is not required below that level. Based on the available data, it is assumed that air emissions from the thermal desorption unit would be below federal standards and would be discharged directly to the atmosphere.

The costs associated with this alternative are as follows:

RAO 1		RAO 2	
Capital Cost:	**$ 1,320,000**	**Capital Cost:**	**$ 2,450,000**
O&M Cost:	**$ 0**	**O&M Cost:**	**$ 0**
Total Cost:	**$ 1,320,000**	**Total Cost:**	**$ 2,450,000**

Table 3-5 presents the advantages and disadvantages of this alternative, in addition to those data required for effective implementation.

Table 3-5
Evaluation of Soil Alternative 2 -- Excavation with Thermal Desorption

Advantages	Disadvantages	Data Requirements
Technically Implementable		**Contaminant Considerations:** • Types and concentrations of fuel-related contaminants, including the fractions of light- and heavy-end hydrocarbons remaining in soil; • Depth profile and distribution of contaminants; • Presence of toxic contaminants (such as pesticides and PCBs); • Presence of VOCs; and • Presence of inorganic contaminants (e.g., metals) **Site/Media Considerations:** • Surface geological features (e.g., topography and vegetative cover); • Subsurface geological and hydrogeological features; • Water availability to support operations of the thermal treatment unit; • Volume of soil requiring remediation; • Soil type, texture, and gradation; • Soil moisture content, water-holding capacity, and dewatering potential; • Soil organic matter content; • Soil cation exchange capacity; and • Soil permeability **Other:** • The State of Alaska generally requires a thermal operations/air impact permit for systems processing more than 5 tons per hour, but such requirements are uncertain at this time • Federal regulations require emissions treatment for systems releasing more than 25 tons total VOCs per year (in addition to thresholds established for individual constituents), but such requirements are uncertain at this time
• No long-term remedial system O&M • Operations can be conducted year-round • Required services and supplies are readily available	• Requires specialized equipment and specially trained personnel. • Mobilization of desorption unit would require a significant effort • Additional soil may be required as a backfill supplement • Habitat restoration would be required following excavation	
Field Proven in Alaska		
• Widely recognized as a viable cleanup alternative in Alaska	• Excavation would be difficult in winter months • Stockpiled soil would have to be covered to minimize increased soil moisture during heavy rain events	
Cost Effective		
• Generally considered to be cost effective when compared to more innovative approaches	• High cost as compared to other alternatives	
Satisfies RAOs		
• Quickly and permanently reduces contaminant concentrations, including heavy-end hydrocarbons • Risk is eliminated after treatment is complete	• None identified	
Community Preference		
• Could be implemented in a short period of time	• Requires specialized equipment and specially trained personnel; little potential exists to create jobs for local residents • Excavation of contaminated soil will disrupt habitat and result in ecological distress; some large diameter trees may have to be removed; habitat restoration would be required	

3.3.1.3 Soil Alternative 3 – Excavation with Composting

This alternative would require the excavation and stockpiling of contaminated soil, composting of the soil at the Main Dock Tank Farm, and backfilling the excavation with clean soil. The limits of excavation would be defined using field screening techniques and confirmed with laboratory analyses.

Composting of soil is preferable to landfarming because composting generates heat which can significantly reduce remediation times. Excavated soil from multiple sites would be stockpiled in windrows and treated as a batch. An area suitable for stockpiling and treating soils for an extended period of time (years) would be designated. Composting the contaminated soil would involve the addition of nutrients and bulking agents, and periodic soil mixing using heavy equipment to ensure aerobic conditions are maintained. The possibility exists to use locally-available wood chips and/or fish wastes in the composting process. Treated soil would be used to encourage vegetative growth at selected locations throughout the area or as non-structural fill.

Access restrictions would be necessary to prevent exposure of contaminants to human and ecological receptors during implementation of the remedial action. Access restrictions could include temporary fencing and/or covering of the treatment piles. Depending on contaminant levels, cleanup may take several years per batch. A treatability study would be required to evaluate remediation times and to determine an optimal mix design.

The costs associated with this alternative are as follows:

RAO 1		RAO 2	
Capital Cost:	**$ 870,000**	**Capital Cost:**	**$ 1,420,000**
O&M Cost:	**$ 0**	**O&M Cost:**	**$ 0**
Total Cost:	**$ 870,000**	**Total Cost:**	**$ 1,420,000**

Table 3-6 presents the advantages and disadvantages of this alternative, in addition to those data required for effective implementation.

Table 3-6
Evaluation of Soil Alternative 3 -- Excavation with Composting

Advantages	Disadvantages	Data Requirements
Technically Implementable		**Contaminant Considerations:** • Types and concentrations of fuel-related contaminants, including the fractions of light- and heavy-end hydrocarbons remaining in soil; • Depth profile and distribution of contaminants; • Presence of toxic contaminants (such as pesticides and PCBs); • Presence of VOCs; and • Presence of inorganic contaminants (e.g., metals) **Site/Media Considerations:** • Surface geological features (e.g., topography and vegetative cover); • Subsurface geological and hydrogeological features; • Temperature, precipitation, wind velocity and direction; • Volume of soil requiring treatment; • Water availability to support composting operations; • The location and availability of borrow sources to allow the immediate backfilling of excavations; • The quantity and availability of fish waste and wood chips to be used in the composting process; • Required hydrocarbon/fish waste/and wood chip ratios for efficient treatment; • Required residence time for the composting process; • Soil type and texture; • Soil moisture content, water-holding capacity, and dewatering potential; • Soil organic matter content; • Soil cation exchange capacity; • Soil nutrient content, pH, and permeability; and • Microorganism populations present at the site, including oil-consuming microbes
• No long-tern remedial system O&M • Operations can be conducted year round • Required services and supplies are readily available	• Requires periodic use of heavy equipment • Additional soil is required for backfill • Treated soil would require onsite disposal	
Field Proven in Alaska		
• Southeast Alaska climate is more favorable as compared to more northern climates	• Limited known application in Alaska • Operations might be difficult in winter months • Would require a treatability study to establish optimum hydrocarbon/fish waste/and wood chip ratios and required residence time to achieve cleanup levels	
Cost Effective		
• Generally considered to be cost-effective	• Moderate cost as compared to other alternatives	
Satisfies RAOs		
• Permanently reduces contaminant concentrations • Risk is eliminated after treatment is complete	• Longer period of time to meet cleanup goals than thermal treatment • May not be effective in reducing heavy-end hydrocarbon concentrations to MIC cleanup levels • Access restrictions are required to mitigate risk while treatment is occurring	
Community Preference		
• May be able to employ local labor force to assist in composting process; potential exists to create jobs • Provides an environmentally sound disposal/recycling option for existing fish and wood chip waste streams present on the island	• Excavation of contaminated soil will disrupt habitat and result in ecological distress, such as the removal of large diameter trees; habitat restoration would be required • Short term access restrictions may be inconvenient to local residents	

3.3.1.4 Soil Alternative 4 – Excavation with Landfarming

This alternative would require the excavation and stockpiling of contaminated soil, landfarming the soil at the Main Dock Tank Farm, and backfilling the excavation with clean soil obtained from a borrow source located on the peninsula. As with the other excavation alternatives, the limits of excavation would be defined using field screening techniques and confirmed with laboratory analyses.

Excavated soil from multiple sites would be stockpiled in windrows and treated as a batch. An area suitable for stockpiling and treating soils for an extended period of time (years) would be designated. Landfarming the contaminated soil would involve periodic mixing or tilling of the soil without the addition of nutrients or bulking agents. Without added nutrients, overall biologic action is reduced, resulted in a longer treatment time before cleanup levels are reached. Treated soil would be used to encourage vegetative growth at select locations throughout the area or as non-structural fill.

As with the composting option, access restrictions would be necessary to prevent exposure of contaminants to human and ecological receptors during implementation of the remedial action. It is anticipated that cleanup would take several years per batch. A treatability study would facilitate a more accurate prediction of remediation times.

The costs associated with this alternative are as follows:

RAO 1

Capital Cost:	**\$ 1,100,000**
O&M Cost:	**\$ 0**
Total Cost:	**\$ 1,100,000**

RAO 2

Capital Cost:	**\$ 1,390,000**
O&M Cost:	**\$ 0**
Total Cost:	**\$ 1,390,000**

Table 3-7 presents the advantages and disadvantages of this alternative, in addition to those data required for effective implementation.

Table 3-7
Evaluation of Soil Alternative 4 – Excavation with Landfarming

Advantages	Disadvantages	Data Requirements
Technically Implementable		**Contaminant Considerations:** • Types and concentrations of fuel-related contaminants, including the fractions of light- and heavy-end hydrocarbons remaining in soil; • Depth profile and distribution of contaminants; • Presence of toxic contaminants (such as pesticides and PCBs); • Presence of VOCs; and • Presence of inorganic contaminants (e.g., metals) **Site/Media Considerations:** • Surface geological features (e.g., topography and vegetative cover); • Subsurface geological and hydrogeological features; • Temperature, precipitation, wind velocity and direction; • Volume of soil requiring treatment; • Water availability to support landfarming operations; • The location and availability of borrow sources to allow the immediate backfilling of excavations; • The quantity and availability of nutrients/fertilizer required for landfarming; • Required hydrocarbon/nitrogen/phosphorus ratios for efficient treatment; • Required residence time for the landfarming process; • Soil type, texture, and gradation; • Soil moisture content, water-holding capacity, and dewatering potential; • Soil organic matter content; • Soil cation exchange capacity; • Soil nutrient content, pH, and permeability; and • Microorganism populations present at the site, including oil-consuming microbes
• No long-term remedial system O&M • No specialized equipment required • Required services and supplies are readily available	• Requires periodic use of heavy equipment • Additional soil is required for backfill • Treated soil would require onsite disposal • Would require the import of fertilizer/nutrients	
Field Proven in Alaska		
• Widely recognized as a viable cleanup alternative in Alaska	• Winter conditions could limit active remediation intervals to only 6 - 8 months per year	
Cost Effective		
• Generally considered to be cost-effective	• Moderate cost as compared to other alternatives	
Satisfies RAOs		
• Permanently reduces contaminant concentrations • Risk is eliminated after treatment is complete	• Longer period of time to meet cleanup goals than thermal treatment or composting • May not be effective in reducing heavy-end hydrocarbon concentrations to MIC cleanup levels • Access restrictions are required to mitigate risk while treatment is occurring	
Community Preference		
• May be able to employ local labor force to assist in landfarming process; the potential exists to create jobs	• Excavation of contaminated soil will disrupt habitat and result in ecological distress, such as the removal of large diameter trees; habitat restoration would be required • Short term access restrictions may be inconvenient to local residents	

3.3.2 Beach Sediment Remedial Alternatives

Similar to soil remedial alternatives, remedial alternatives developed for beach sediment consider the scope required to achieve each of the RAOs developed in Section 2 of this report. For the purposes of estimating cost, it is assumed that the cost to achieve RAO 1 (risk reduction) would require remediation of 33 percent of the potentially impacted soil volume (approximately 15,000 cubic yards). To achieve RAO 2 (compliance with MIC cleanup levels), it is assumed that 67 percent of the potentially impacted soil volume would require remediation (roughly 30,000 cubic yards).

3.3.2.1 Beach Sediment Alternative 1 – Monitored Natural Attenuation

Access restrictions include restrictions such as deed or water rights restrictions, land use restrictions, and land purchase restrictions. Physical controls, such as erecting a perimeter fence to prevent site access, might also be included. As with the remediation of soil (Section 3.3.1.1), access restrictions would be combined with natural attenuation (degradation by natural physical, biological or chemical processes without additional treatment). Natural attenuation diminishes constituent concentrations and consequently reduces the risk to potential receptors.

Microbial degradation of petroleum hydrocarbons is a well-documented, cost-effective remedial method. Organic compounds are oxidized through various electron-exchange reactions. This process can also be successful for solvents and other types of organic contamination, but is not as favorable for contaminants such as pesticides or metals. Indicator parameters such as iron and manganese can be monitored to track the degradation of fuel-related compounds.

Monitoring to ensure that the alternative remains protective of human health and the environment is an essential part of this remedy. For beach sediments, monitoring would occur through the collection of surface sediment samples collected annually in designated areas of known contamination. The list of sample analytes would typically include those that are used to document and quantify the process of natural attenuation, as well as those which detect the presence of fuel-related compounds. Implementation of a long-term monitoring program would be conducted in accordance with an approved plan. As part of the long-term monitoring plan, modeling could be used to determine the rate at which contaminants should degrade. If monitoring indicates that contaminants are not degrading at an acceptable rate, additional, more aggressive treatment technologies could be used.

The costs associated with this alternative are as follows:

RAO 1	
Capital Cost:	**$ 0**
O&M Cost:	**$ 180,000**
Total Cost:	**$ 180,000**

RAO 2	
Capital Cost:	**$ 0**
O&M Cost:	**$ 240,000**
Total Cost:	**$ 240,000**

Table 3-8 presents the advantages and disadvantages of this alternative, in addition to those data required for effective implementation.

Table 3-8
Evaluation of Beach Sediment Alternative 1 – Monitored Natural Attenuation

Advantages	Disadvantages	Data Requirements
Technically Implementable		**Contaminant Considerations:** • Types and concentrations of fuel-related contaminants, including the fractions of light- and heavy-end hydrocarbons remaining in beach sediment; • Depth profile and distribution of contaminants, including the presence of contamination in subtidal sediments; • Presence of toxic contaminants (such as pesticides and PCBs); • Presence of ordinances buried in sediment; • Presence of VOCs; and • Presence of inorganic contaminants (e.g., metals) **Soil and Groundwater Geochemical Considerations:** • Geochemical data to assess the potential for biodegradation of the contaminants **Site/Media Considerations:** • Lithology and stratigraphic relationships; • Grain-size distribution (sand vs. silt vs. clay); • Flow gradient; • Preferential flow paths; • Interaction between groundwater and surface water; • Temperature, precipitation, wind velocity and direction; • Water availability; • Soil moisture content; • Soil organic matter content; • Soil cation exchange capacity; • Soil nutrient content, pH, and permeability; and • Microorganism populations present at the site, including oil-consuming microbes
• Local personnel can be trained to conduct monitoring events • No equipment to maintain • No operation or activity required in winter months • Required services and supplies are readily available	• Sampling equipment and supplies would have to mobilized to the site on a regular basis • Samples would have to be sent offsite for analysis	
Field Proven in Alaska		
• Widely recognized as a viable cleanup alternative in Alaska • Southeast Alaska climate is more favorable as compared to more northern site locations	• None	
Cost Effective		
• Generally considered to be cost-effective • The least expensive alternative	• None	
Satisfies RAOs		
• Permanently reduces contaminant concentrations over time • Access restrictions would mitigate risk to human health during cleanup	• Long time to reach cleanup levels • Risk to some wildlife (such as birds and water fowl) would be difficult to mitigate while RAOs are being met	
Community Preference		
• The potential exists to create a limited number of jobs for local residents • No impact to local flora or fauna	• Access restrictions may be inconvenient to local residents	

3.3.2.2 Beach Sediment Alternative 2 – Beach Sediment Excavation, Dewatering, and Thermal Desorption

This alternative involves the removal of beach sediments by use of a hydraulic excavator to a depth of approximately 2 feet bgs, and would be conducted during low tide events. No excavation of subtidal sediments would be required; however, such excavation could be supported through the use of a hydraulic excavator mounted on a floating platform (i.e., barge) if required. Access restrictions to the beach during excavation would be required to prevent potential short-term exposure to contaminants.

Excavated sediments would be stockpiled in a holding cell designed to facilitate passive dewatering. Ideally, effluent from dewatering activities would be collected for treatment through the treatment system installed as part of the groundwater remedy, or treated using carbon adsorption if the timing between the implementation of soil and water remedial alternatives is not favorable. Ideally, beach sediments would be treated using the same technology selected for soil (i.e., thermal desorption, composting, or landfarming). However, it is anticipated that mainly heavy-end hydrocarbons remain in the sediments and would be best treated using a thermal technique; therefore, thermal desorption was conservatively assumed as for cost estimating purposes. The resulting clean material could be used as fill for other areas, and are not anticipated to be placed back onto the beach as material placement could cause surface water in Tamgas Harbor to become turbid; thermally treated soil would also be rendered biologically neutral. Similar to the soil excavation alternatives, the area to be excavated would be defined using field screening techniques and confirmed with laboratory analyses.

The costs associated with this alternative are as follows:

RAO 1

Capital Cost:	**$ 5,700,000**
O&M Cost:	**$ 0**
Total Cost:	**$ 5,700,000**

RAO 2

Capital Cost:	**$ 10,280,000**
O&M Cost:	**$ 0**
Total Cost:	**$ 10,280,000**

Table 3-9 presents the advantages and disadvantages of this alternative, in addition to those data required for effective implementation.

Table 3-9
Evaluation of Beach Sediment Alternative 2 – Beach Sediment Excavation, Dewatering, and Thermal Desorption

Advantages	Disadvantages	Data Requirements
Technically Implementable		**Contaminant Considerations:** • Types and concentrations of fuel-related contaminants, including the fractions of light- and heavy-end hydrocarbons remaining in beach sediment; • Depth profile and distribution of contaminants, including the presence of contamination in subtidal sediments; • Presence of toxic contaminants (such as pesticides and PCBs); • Presence of ordinances buried in sediment; • Presence of VOCs; and • Presence of inorganic contaminants (e.g., metals) **Site/Media Considerations:** • Beach geological features (e.g., topography and vegetative cover); • Subsurface geological and hydrogeological features; • Temperature, precipitation, wind velocity and direction; • Water availability to support operations of the thermal treatment unit; • Volume of soil requiring remediation; • Sediment type, texture, and gradation; • Soil moisture content, water-holding capacity, and dewatering potential; • Sediment organic matter content; • Sediment cation exchange capacity; • Sediment nutrient content, pH, and permeability; and • Microorganism populations present at the site, including oil-consuming microbes **Other:** • The State of Alaska generally requires a thermal operations/air impact permit for systems processing more than 5 tons per hour, but such requirements are uncertain at this time • Federal regulations require emissions treatment for systems releasing more than 25 tons total VOCs per year (in addition to thresholds established for individual constituents), but such requirements are uncertain at this time
• No long-term remedial system O&M • Operations can be conducted year-round • Could be used to address subtidal sediments using a different excavation technique • Required services and supplies are readily available	• Requires periodic use of heavy equipment • Tidal fluctuations would limit excavation work hours • Additional soil may be required as a backfill supplement; thermally treated soil would be rendered biologically neutral	
Field Proven in Alaska		
• Widely recognized as a viable cleanup alternative in Alaska	• Excavation would be difficult in winter months due to potentially large amounts of rain • Stockpiled sediment would have to be covered to minimize increased soil moisture during heavy rain events	
Cost Effective		
• Generally considered to be cost effective when compared to more innovative approaches	• High cost as compared to other alternatives	
Satisfies RAOs		
• Permanently reduces contaminant concentrations, including heavy-end hydrocarbons • Risk is eliminated after treatment is complete	• Access restrictions are required to mitigate risk during treatment operations	
Community Preference		
• Limited potential exists to create jobs for local residents; however, may be able to employ local labor force to assist in excavation	• Subsistence use at the beach would be suspended while RAOs are being met • Dredging of contaminated soil will disrupt habitat and result in some ecological distress; habitat restoration would be required	

3.3.2.3 Beach Sediment Alternative 3 – In situ Landfarming

This alternative would require the periodic tilling of beach sediments using heavy equipment at low tide. The area requiring manipulation would be defined using field screening techniques and confirmed with laboratory analyses. Mixing or tilling of the beach sediments would allow contaminants which are currently buried to be exposed to air and sunlight to stimulate natural attenuation of the petroleum contaminants by biological processes. Aeration of the beach sediments should also increase their viability as a habitat for nearshore marine species. Turning of the sediments will also expose contaminants to wave and tidal action so that physical processes such as dilution and dispersion can also help to naturally attenuate the contaminants present.

As with soil, landfarming of beach sediments would involve periodic mixing or tilling without the addition of nutrients or bulking agents. To be effective, the frequency of tilling events would be greater than what would be considered typical of onshore landfarming techniques because of the anticipated effects of tidal action. Access restrictions, which would likely include beach closure, would be necessary to prevent exposure of contaminants to human and ecological receptors during implementation of the remedial action.

Cost assumptions used for RAO 1 compliance assume that not measures would be taken to prevent the potential migration of site contaminants into Tamgas Harbor during the action. For RAO 2, it is assumed that sediment containment would be required to provide additional protection of environmental receptors in Tamgas Harbor. For cost estimating purposes, it is assumed that a sheet pile containment structure would be installed to a depth of 30 feet along 2,000 feet of beach front at a distance of 500 feet from the shore; 3,000 lineal feet of sheet piling would be required.

The costs associated with this alternative are as follows:

RAO 1	
Capital Cost:	**$ 1,000,000**
O&M Cost:	**$ 0**
Total Cost:	**$ 1,000,000**

RAO 2	
Capital Cost:	**$ 4,800,000**
O&M Cost:	**$ 0**
Total Cost:	**$ 4,800,000**

Table 3-10 presents the advantages and disadvantages of this alternative, in addition to those data required for effective implementation.

Table 3-10
Evaluation of Beach Sediment Alternative 3 – In situ Landfarming

Advantages	Disadvantages	Data Requirements
Technically Implementable		**Contaminant Considerations:** • Types and concentrations of fuel-related contaminants, including the fractions of light- and heavy-end hydrocarbons remaining in beach sediment; • Depth profile and distribution of contaminants, including the presence of contamination in subtidal sediments; • Presence of toxic contaminants (such as pesticides and PCBs); • Presence of ordinances buried in sediment; • Presence of VOCs; and • Presence of inorganic contaminants (e.g., metals) **Site/Media Considerations:** • Surface geological features (e.g., topography and vegetative cover); • Subsurface geological and hydrogeological features; • Temperature, precipitation, wind velocity, and direction; • Sediment type, texture, and gradation; • Sediment moisture content; • Sediment organic matter content; • Sediment cation exchange capacity and water-holding capacity; • Sediment nutrient content, pH, and permeability; • The depth to bedrock to allow for sheet piling containment structures; and • Microorganism populations present at the site, including oil-consuming microbes
• No long-term remedial system O&M • Required services and supplies are readily available	• Requires periodic use of heavy equipment • Operations would be limited to non-winter months • Tidal action may result in limited effectiveness requiring frequent tilling events • Cannot be used to address subtidal sediments	
Field Proven in Alaska		
• Large tidal fluctuations experienced in Alaska would help disperse contaminants to help biological remediation	• Unproven under these conditions in Alaska	
Cost Effective		
• Generally considered to be cost effective	• Moderate cost	
Satisfies RAOs		
• Permanently reduces contaminant concentrations • Risk is eliminated after treatment is complete	• Relies heavily on dilution and dispersion for remediation of contaminants; may be difficult to obtain regulatory approval • Moderate period of time to meet cleanup goals than more aggressive treatments; may not be effective on heavy-end hydrocarbons • Risk to marine life (such as shellfish) would be difficult to mitigate while RAOs are being met	
Community Preference		
• The potential exists to create jobs for local residents	• Subsistence use at the beach would likely be suspended while RAOs are being met	

3.3.3 Surface Water and Groundwater Remedial Alternatives

Remedial alternatives developed for water consider the scope required to achieve each of the RAOs developed in Section 2 of this report. For the purposes of estimating cost, it is assumed that the cost to achieve RAO 1 (risk reduction) would require a remediation time of approximately 15 years, unless stated otherwise. Further, it is assumed that the remedial alternative would require 30 years to achieve compliance with MIC cleanup levels (RAO 2), unless stated otherwise. These remediation times assume that sources of groundwater contamination have been mitigated and the contaminant flux entering groundwater is equal to zero. Because the magnitude of groundwater contamination has not been defined at the time of preparing this report, it is assumed that groundwater treatment systems would be of comparable size required to comply with either RAO. The following paragraphs describe the remedial alternatives proposed for water at the Main Dock Tank Farm.

3.3.3.1 Water Alternative 1 -- Access Restrictions with Monitored Natural Attenuation

Access restrictions include restrictions such as deed or water rights restrictions, land use restrictions, and land purchase restrictions. As with the remediation of soil (Section 3.3.1.1), access restrictions would be combined with natural attenuation (degradation by natural physical, biological, or chemical processes without active treatment). Natural attenuation is a well-documented, cost-effective remedial method for the remediation of fuel-related compounds that reduces the potential risk to site contaminants and eventually diminishes constituent concentrations to cleanup levels. This process can also be successful for solvents and other types of organic contamination, but is not as favorable for contaminants such as pesticides or metals.

For groundwater, monitoring would occur through the installation of groundwater monitoring wells at key locations and the collection and analysis of groundwater samples on an annual basis. The list of sample analytes would typically include those that are used to document and quantify the process of natural attenuation (such as iron and manganese), as well as those which detect the presence of dissolved fuel. Implementation of a long-term monitoring program would be conducted in accordance with an approved plan. As part of the long-term monitoring plan, modeling could be used to determine the rate at which contaminants should degrade. If monitoring indicates that contaminants are not degrading at an acceptable rate, additional, more aggressive treatment technologies could be used.

The estimated costs for this alternative are as follows:

RAO 1		RAO 2	
Capital Cost:	**$ 90,000**	**Capital Cost:**	**$ 90,000**
O&M Cost:	**$ 340,000**	**O&M Cost:**	**$ 460,000**
Total Cost:	**$ 430,000**	**Total Cost:**	**$ 550,000**

Table 3-11 presents the advantages and disadvantages of this alternative, in addition to those data required for effective implementation.

Table 3-11
Evaluation of Water Alternative 1 – Access Restrictions with Monitored Natural Attenuation

Advantages	Disadvantages	Data Requirements
Technically Implementable		**Contaminant Considerations:** • Types and concentrations of fuel-related contaminants in surface water and groundwater, including the fraction of light- and heavy-end hydrocarbons; • Areal extent and depth of groundwater contamination; • Presence of toxic contaminants (such as pesticides); • Presence of VOCs; and • Presence of inorganic contaminants (e.g., metals) **Soil (Saturated Zone) and Groundwater Geochemical Considerations:** • Geochemical data to assess the potential for biodegradation of the contaminants **Site / Media Considerations:** • Lithology and stratigraphic relationships, including the presence of the clay layer believed to be present across the site; • Grain-size distribution and permeability (sand vs. silt vs. clay); • Flow gradient; • Preferential flow paths; • Interaction between groundwater and surface water; • Temperature, precipitation, wind velocity and direction; • Location of drinking water sources and the availability of alternate water supplies; • Saturated zone soil moisture content; • Saturated zone soil organic matter content; • Saturated zone soil cation exchange capacity and water-holding capacity; • Saturated zone soil nutrient content, and pH; and • Microorganism populations present at the site, including the presence of oil-consuming microbes.
• Local personnel can be trained to conduct monitoring events • No equipment to maintain • No operation or activity required in winter months • Required services and supplies are readily available	• Sampling equipment and supplies would have to mobilized to the site on a regular basis • Samples would have to be sent offsite for analysis	
Field Proven in Alaska		
• Widely recognized as a viable cleanup alternative in Alaska • Southeast Alaska climate is more favorable as compared to more northern site locations	• None	
Cost Effective		
• Generally considered to be cost-effective • The least expensive alternative	• None	
Satisfies RAOs		
• Permanently reduces contaminant concentrations over time • Access restrictions would mitigate risk to human health during cleanup	• Long time to reach cleanup levels • Risk to some wildlife (such as birds and water fowl) would be difficult to mitigate while RAOs are being met • Alternate drinking water supply might be necessary	
Community Preference		
• The potential exists to create a limited number of jobs for local residents • No impact to local flora or fauna	• Access restrictions may be inconvenient to local residents	

3.3.3.2 Water Alternative 2 – Constructed Wetlands Treatment

This alternative would involve the capture of contaminated groundwater at the Main Dock Tank Farm and treatment of the water using a passive wetland system. Groundwater would be captured using interceptor trenches installed downgradient of the areas of known contamination. Two interceptor trenches, each 250 feet in length, would be installed to capture contaminated groundwater, and would be equipped with an oil/water separator to remove free product prior to entering the wetland area. The trenches would be installed to a depth of 10 feet bgs, just above the clay layer believed to be present across the site. Surface water could also enter the wetland system for treatment, if required. Treated water would be sampled and re-injected underground to a depth of 40 feet bgs. Treated water could also be injected into shallow groundwater upgradient of contaminant sources in an effort to reduce the required remediation time through soil flushing; surfactants could also be used to accelerate this process.

An engineered wetland system passively degrades petroleum hydrocarbons as water flows through the system, which is enhanced by the presence of indigenous plants within the wetland area. The hydraulic residence time is controlled by the wetland areal size and gradient, and can also be controlled through the use of a weir. Plant structures help trap contaminants to increase contaminant residence time to allow for efficient microbial contaminant degradation. The treatment system is assumed to require an area of approximately 10,000 square feet to achieve a hydraulic residence time of 1 day, assuming a total influent rate of 150 gpm. Site-specific conditions would dictate the required wetland area for efficient groundwater treatment.

This alternative would require a moderately high capital expense for the installation of the required systems. Operation and maintenance costs, because the systems are passive, would be relatively low.

The estimated costs for this alternative are as follows:

RAO 1	
Capital Cost:	**$ 1,330,000**
O&M Cost:	**$ 2,500,000**
Total Cost:	**$ 3,830,000**

RAO 2	
Capital Cost:	**$ 1,330,000**
O&M Cost:	**$ 3,380,000**
Total Cost:	**$ 4,710,000**

Table 3-12 presents the advantages and disadvantages of this alternative, in addition to those data required for effective implementation.

Table 3-12
Evaluation of Water Alternative 2 – Constructed Wetlands Treatment

Advantages	Disadvantages	Data Requirements
Technically Implementable		**Contaminant Considerations:** • Types and concentrations of fuel-related contaminants in surface water and groundwater, including the fraction of light- and heavy-end hydrocarbons; • The presence of free product in groundwater; • Areal extent and depth of groundwater contamination; • Presence of toxic contaminants (such as pesticides); • Presence of VOCs; and • Presence of inorganic contaminants (e.g., metals) **Site/Media Considerations:** • Lithology and stratigraphic relationships, including the presence of a clay layer believed to be present across the site; • Grain-size distribution (sand vs. silt vs. clay); • Preferential flow paths; • Water hardness and iron content for system fouling considerations; • Interaction between groundwater and surface water; • Subsurface geological and hydrogeological features (depth to groundwater, flow direction, gradient, probable well yield, draw-down potential, etc.); • Saturated zone soil type, texture and permeability; • Saturated zone soil organic matter content; • Saturated zone soil cation exchange capacity and water-holding capacity; • Saturated zone soil and groundwater nutrient content, and pH; • Microorganism populations present at the site, including oil-consuming microbes; and • The availability of indigenous plant species that would provide efficient contaminant retention time and efficient treatment **Other:** • A permit to inject treated water to the subsurface typically requires an underground injection permit issued by the EPA, but such requirements are uncertain for this site
• The system could operate year-round • Passive systems are relatively easy to maintain • Required services and supplies are readily available	• Requires specialized design and construction equipment • Mobilization of the required materials might be difficult • Underground injection may require multi-well injection • Requires power to operate pumping systems • The presence of free product, VOCs, and/or pesticides may require additional treatment steps e.g., oil/water separation, aeration basins, and carbon polishing, respectively) • Would require snow removal for year-round access to the treatment system	
Field Proven in Alaska		
• Successfully implemented in Alaska • Southeast Alaska climate is more favorable as compared to more northern site locations	• Significant site-specific data gaps must be filled before alternative considered effective	
Cost Effective		
• Generally considered cost effective when compared to traditional treatment techniques	• Moderate cost	
Satisfies RAOs		
• Permanently reduces contaminant concentrations • Risk is eliminated after treatment is complete	• Longer period of time to meet cleanup goals than more aggressive treatment options	
Community Preference		
• The potential exists to create jobs for local residents during construction and for the duration of system O&M • A constructed wetland would enhance the existing habitat	• Implementation of the interceptor trenches will disrupt habitat and result in ecological distress; the removal of some large diameter trees in the area may be required • Access restrictions would likely be required around the groundwater treatment system	

3.3.3.3 Water Alternative 3 -- Carbon Adsorption Treatment

This alternative would be very similar to Water Alternative 2 (Section 3.3.3.2), except that carbon adsorption would be used in the water treatment process instead of constructing an engineered wetlands. Groundwater would be captured using interceptor trenches and treated water injected to the subsurface as previously described. A carbon adsorption treatment system with a series of vessels filled with activated granular carbon would be used for water treatment. Two vessels would be installed in series to ensure effective treatment. The first vessel would provide primary removal of contaminants while the second vessel would provide 'polishing' and a redundant control in the event that the first vessel reaches its adsorbing capacity.

Carbon adsorption is a natural process in which dissolved phase hydrocarbons are physically attracted to and held at the surface of activated carbon. The carbon is typically supplied in a granular form to maximize the surface area available for adsorbing contaminants. Carbon is effective in removing a wide variety of contaminants from water, including fuel-related compounds, pesticides, lead, and solvents.

This alternative would require a moderately high capital expense for the installation of the interceptor trenches, the carbon treatment system, and the water discharge system. Operation and maintenance costs would also be moderately high since large quantities of carbon would be required to effectively treat the anticipated volume of water; the carbon is assumed to require replacement at quarterly intervals.

The estimated costs for this alternative are as follows:

RAO 1	
Capital Cost:	**$ 770,000**
O&M Cost:	**$ 4,130,000**
Total Cost:	**$ 4,900,000**

RAO 2	
Capital Cost:	**$ 770,000**
O&M Cost:	**$ 5,580,000**
Total Cost:	**$ 6,350,000**

Table 3-13 presents the advantages and disadvantages of this alternative, in addition to those data required for effective implementation.

Table 3-13
Evaluation of Water Alternative 3 -- Carbon Adsorption Treatment

Advantages	Disadvantages	Data Requirements
Technically Implementable		**Contaminant Considerations:** • Types and concentrations of fuel-related contaminants in surface water and groundwater, including the fraction of light- and heavy-end hydrocarbons; • The presence of free product in groundwater; • Areal extent and depth of groundwater contamination; • Presence of toxic contaminants (such as pesticides); • Presence of VOCs; and • Presence of inorganic contaminants (e.g., metals) **Site/Media Considerations:** • Lithology and stratigraphic relationships, including the presence of a clay layer believed to be present across the site; • Grain-size distribution (sand vs. silt vs. clay); • Preferential flow paths; • Water hardness and iron content for system fouling considerations; • Interaction between groundwater and surface water; • Subsurface geological and hydrogeological features (depth to groundwater, flow direction, gradient, probable well yield, draw-down potential, etc.); • Saturated zone soil type, texture and permeability; • Saturated zone soil organic matter content; • Saturated zone soil cation exchange capacity and water-holding capacity; • Saturated zone soil and groundwater nutrient content, and pH; and • Microorganism populations present at the site, including oil-consuming microbes **Other:** • A permit to inject treated water to the subsurface typically requires an underground injection permit issued by the EPA, but such requirements are uncertain for this site
• Systems could be designed and constructed to operate year-round • Required services and supplies are readily available	• Requires specialized design and construction equipment • Underground disposal may require multi-well injection field • An excessive amount of carbon may be required for effective treatment • Requires power to operate pumping systems • The presence of free product, VOCs, and/or pesticides may require additional treatment steps (e.g., oil/water separation, aeration basins, and carbon polishing, respectively) • Would require snow removal for year-round access to the treatment system	
Field Proven in Alaska		
• Successfully implemented in Alaska	• Significant site-specific data gaps must be filled before alternative considered effective	
Cost Effective		
• Low capital cost	• The most expensive alternative • High O&M cost	
Satisfies RAOs		
• Permanently reduces contaminant concentrations • Risk is eliminated after treatment is complete	• Longer period of time to meet cleanup goals than more aggressive treatment options	
Community Preference		
• The potential exists to create jobs for local residents during construction and for the duration of system O&M	• Implementation of the interceptor trenches will disrupt habitat and result in ecological distress; the removal of some large diameter trees in the area may be required • Access restrictions would likely be required around the groundwater treatment system	

3.3.3.4 Water Alternative 4 –Water Diversion

The use of surface or shallow groundwater diversion structures can reduce offsite contaminant migration by reducing the contact of clean water with contaminated soil and channel water into or away from preferential flow paths. At the Main Dock Tank Farm, surface water or shallow groundwater frequently contributes to the marshy conditions at the site. Eventually, this water may come in contact with contaminated soil and have the potential to become cross-contaminated. This condition could be avoided by diverting the flow of surface water or shallow groundwater away from the contaminated areas. Diversion structures can also be used to divert contaminated water away from viable aquifers.

Diversion structures may include sheet piles, slurry walls (a free-flowing mixture of Portland Cement and grout that would harden into an impermeable wall), French drains, or intercept trenches. It is assumed that sheet pile structures would be installed perpendicular to the surface water/groundwater gradient upgradient of the Standard Oil Tank Farm with a minimum length of 1,000 lineal feet and to a depth of 15 feet bgs (i.e., below the clay layer suspected to be present across the site). A detailed analysis of the surface water and shallow groundwater hydrology at each location would be required.

This alternative would require a low capital expense for the construction of a diversion structure. Since the system would be primarily passive, operation and maintenance costs would be minimal. The costs associated with this alternative are estimated based on a remediation time frame of 15 years to comply with RAO 1; conversely, it is assumed that it would take 30 years to reach compliance with MIC cleanup levels (RAO 2).

The estimated costs for this alternative are as follows:

RAO 1

Capital Cost:	**$ 540,000**
O&M Cost:	**$ 60,000**
Total Cost:	**$ 600,000**

RAO 2

Capital Cost:	**$ 540,000**
O&M Cost:	**$ 80,000**
Total Cost:	**$ 620,000**

Table 3-14 presents the advantages and disadvantages of this alternative, in addition to those data required for effective implementation.

Table 3-14
Evaluation of Water Alternative 4 – Water Diversion

Advantages	Disadvantages	Data Requirements
Technically Implementable		**Contaminant Considerations:** • Types and concentrations of fuel-related contaminants in surface water and groundwater, including the fraction of light- and heavy-end hydrocarbons; • Upgradient contaminant sources, and the presence of upgradient contamination; • The presence of free product in groundwater; • Areal extent and depth of groundwater contamination; • Presence of toxic contaminants (such as pesticides); • Presence of VOCs; and • Presence of inorganic contaminants (e.g., metals) **Site/Media Considerations:** • Lithology and stratigraphic relationships, including the presence of a clay layer believed to be present across the site; • Grain-size distribution (sand vs. silt vs. clay); • Preferential flow paths; • The need for cathodic protection; • The presence of shallow bedrock outcrops or large boulders in the subsurface; • Interaction between groundwater and surface water; • Subsurface geological and hydrogeological features (depth to groundwater, flow direction, gradient, probable diversion potential, etc.); • Saturated zone soil type, texture and permeability; and • Saturated zone soil organic matter content and soil structural properties
• Systems could operate year-round. • Passive systems are easy to maintain • Required services and supplies are readily available	• Requires specialized construction equipment • Mobilization of the required materials and equipment might be difficult • Presence of shallow bedrock or large boulders would limit effectiveness	
Field Proven in Alaska		
• Successfully implemented in Alaska • Passive systems are easy to maintain	• None	
Cost Effective		
• Low cost	• None	
Satisfies RAOs		
• Quickly isolates contaminated water and diverts clean water away • Permanently reduces contaminant concentrations • Risk is eliminated after treatment is complete	• Longer period of time to meet cleanup goals than more aggressive treatment options • Alternate drinking water supply might be necessary	
Community Preference		
• Limited job potential for local residents	• Access roads would have to be constructed to install diversion structures; would cause limited impact to local flora and fauna	

3.3.3.5 Water Alternative 5 – Oxygen-Releasing Compounds

Bioremediation with oxygen releasing compounds is an in situ groundwater remediation technology which increases the level of dissolved oxygen available for natural attenuation. Increasing oxygen levels increases biologic activity, speeding the process by which contaminants are destroyed. The commonly used types of oxygen-releasing compounds include ozone, hydrogen peroxide, and magnesium peroxide.

To implement this alternative, monitor wells would be installed to identify areas where groundwater contamination is present; oxygen-releasing compounds could be added to these wells. In addition, oxygen-releasing compounds could be added to the bottom of soil or beach sediment excavations prior to backfilling if an ex situ treatment option were selected. This technology is best suited for use in areas where groundwater flow is relatively slow. A detailed analysis of the surface water hydrology at each proposed location would be required.

For the purposes of estimating the cost of this alternative, it is assumed that 48 oxygen-releasing compound wells would be required at the Main Dock Tank Farm, with 24 downgradient monitor wells to monitor remedial parameters. Site-specific conditions would determine the area of influence of each well, which will dictate well spacing and the number of wells required.

Oxygen-releasing compounds would require a moderately high capital expense for the installation of the required wells and moderately high O&M costs, which would include periodic replacement of the oxygen-releasing compounds and sampling. The costs associated with this alternative are estimated based on a remediation time frame of 5 years to comply with RAO 1; conversely, it is assumed that it would take 10 years to reach compliance with MIC cleanup levels (RAO 2).

The estimated costs for this alternative are as follows:

RAO 1	
Capital Cost:	**$ 880,000**
O&M Cost:	**$ 1,100,000**
Total Cost:	**$ 1,980,000**

RAO 2	
Capital Cost:	**$ 880,000**
O&M Cost:	**$ 1,880,000**
Total Cost:	**$ 2,760,000**

Table 3-15 presents the advantages and disadvantages of this alternative, in addition to those data required for effective implementation.

Table 3-15
Evaluation of Water Alternative 5 – Oxygen-Releasing Compounds

Advantages	Disadvantages	Data Requirements
Technically Implementable		**Contaminant Considerations:** • Types and concentrations of fuel-related contaminants in surface water and groundwater, including the fraction of light- and heavy-end hydrocarbons; • The presence of free product in groundwater; • Areal extent and depth of groundwater contamination; • Presence of toxic contaminants (such as pesticides); • Presence of VOCs; and • Presence of inorganic contaminants (e.g., metals) **Site/Media Considerations:** • Lithology and stratigraphic relationships, including the presence of a clay layer believed to be present across the site; • Grain-size distribution (sand vs. silt vs. clay); • Preferential flow paths; • Water hardness and iron content for system fouling considerations; • Interaction between groundwater and surface water; • Subsurface geological and hydrogeological features (depth to groundwater, flow direction, gradient, probable well yield, draw-down potential, etc.); • Saturated zone soil type, texture and permeability; • Saturated zone soil organic matter content; • Saturated zone soil cation exchange capacity and water-holding capacity; • Saturated zone soil and groundwater nutrient content, and pH; and • Microorganism populations present at the site, including oil-consuming microbes **Other:** • A permit to inject substances to the subsurface typically requires an underground injection permit issued by the EPA, but such requirements are uncertain for this site
• Systems could operate year-round • Speculated low groundwater flow conditions/shallow gradient is favorable for this technology • ORC wells are relatively easy to install; required services and supplies are readily available	• Requires specialized design and construction equipment • A large number of wells might be required for technology to be effective • Would require snow removal for year-round access to well fields	
Field Proven in Alaska		
• Limited success in Alaska; however, southeast Alaska climate may favor this technology as compared to sites located at more northern locations	• Significant site-specific data gaps must be filled before alternative considered effective	
Cost Effective		
• No major excavation or treatment facility construction costs	• Moderate cost	
Satisfies RAOs		
• Permanently reduces contaminant concentrations • Risk is eliminated after treatment is complete • Could also remediate inter-tidal and subtidal sediments through downgradient propagation of dissolved oxygen in the subsurface	• Longer period of time to meet cleanup goals than more aggressive treatment options	
Community Preference		
• May be able to employ local labor force to assist in well construction and sampling • Limited potential to create jobs for local residents	• Some impact to local flora and fauna would result from well installation	

3.3.4 Comparative Evaluation

The selected remedial alternatives were further evaluated against the screening criteria presented in Section 3.2 to help determine which alternative might be best suited for application at the Main Dock Tank Farm. The evaluation qualitatively assesses each alternative in terms of the scoring criteria presented in Section 3.2, which is further explained in Table 3-16. Table 3-17 presents the results of the comparative evaluation in terms of the scoring criteria.

Table 3-16
Remedial Alternative Scoring Criteria

Evaluation Criteria	**Scoring Criteria**		
			
Technically Implementable	• The alternative would be easy to design, construct, and operate	• The alternative would be fairly easy to moderately difficult to design, construct, and operate	• The alternative would be difficult to design, construct, and operate
Field Proven in Alaska	• The alternative has had great success at other contaminated sites in Alaska	• The alternative has had good success at other contaminated sites in Alaska	• The alternative has had limited success at other contaminated sites in Alaska
Cost-Effective	• The alternative is the least expensive to design, construct, and operate	• The alternative is moderately expensive to design, construct, and operate	• The alternative is the most expensive to design, construct, and operate
Satisfies RAOs	• The alternative would satisfy both RAOs in a short period of time	• The alternative would satisfy RAO 1 in a short period of time; and • The alternative would satisfy RAO 2 in a long period of time	• The alternative would satisfy both RAOs in a long period of time
Community Preference	• The alternative would create jobs for local residences • The alternative would cause little or no adverse impacts to the local community or environment	• The alternative would create limited jobs for local residents • The alternative would cause limited adverse impacts to the local community or environment	• The alternative would not create jobs for local residents (i.e., the alternative requires a specially trained labor force or no labor at all) • The alternative would cause adverse impacts to the local community or environment

Table 3-17
Comparative Evaluation of Remedial Alternatives

Remedial Alternative	Screening Criteria				
	Technically Implementable	Field Proven in Alaska	Cost Effective	Satisfies RAOs	Community Preference
Soil					
Access restrictions with monitored natural attenuation	👍	👍	👍	👌	👎
Excavate, thermal desorption, backfill excavation	👎	👍	👎	👍	👎
Excavate, composting, onsite disposal	👍	👌	👌	👌	👍
Excavate, land farming, onsite disposal	👌	👌	👌	👌	👍
Beach Sediment					
Access restrictions with monitored natural attenuation	👍	👍	👍	👌	👎
Excavation, sediment dewatering, sediment treatment, water treatment	👌	👌	👎	👍	👌
In situ landfarming	👍	👎	👌	👌	👎
Water					
Access restrictions with monitored natural attenuation	👍	👍	👍	👌	👎
Interception trench, constructed wetlands, underground injection	👌	👍	👎	👍	👍
Interception trench, carbon treatment, underground injection	👌	👍	👎	👍	👌
Water diversion	👌	👍	👌	👎	👌
In situ treatment using oxygen-releasing compounds	👍	👌	👎	👌	👎

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4.0 CONCLUSIONS AND RECOMMENDATIONS

The alternatives identified in this document are considered preliminary; they will be used for planning purposes and to help focus future data collection efforts. Results from future data collection efforts will be used to further refine the remedial approach of the Main Dock Tank Farm; therefore, this document should be considered a 'living document" that can be easily modified to incorporate new data as they become available.

However, on the basis of existing data, the following remedial alternatives may be the most cost-effective and acceptable long-term solutions to remediate soil, beach sediment, and water as follows:

- Soil – excavation of contaminated soil with composting;
- Beach sediment – excavation with soil treatment using the selected soil treatment technology; and
- Water – collection of groundwater exhibiting gross contamination, treatment using a constructed wetlands, and underground injection. Limited diversion of uncontaminated surface water and shallow groundwater upgradient of the treatment system is also recommended to help minimize the quantity of water requiring treatment.

It should be noted that a cost-effective remedial approach would involve implementing remedial alternatives for one media in a manner that minimizes the cost of remediating other media. For example, excavated areas at the Standard Oil Tank Farm could be converted into constructed wetland treatment cells; the excavation costs between the two alternatives would be shared, thereby reducing the overall remedial program cost. In addition, economies of scale might be realized if all soil and beach sediment are treated using the same technique. At this time, thermal treatment appears to be the technique that could be universally applied to both soil and sediment, as constituent composition in beach sediment is speculated be primarily heavy-end hydrocarbons; these compounds may not respond well to bioremediation techniques (i.e., landfarming or composting). Other cost reduction methodologies should continue to be pursued during the time which a final remedy is selected for the Main Dock Tank Farm.

Prior to implementing full-scale remedial actions at the Main Dock Tank Farm, treatability studies are recommended. For the composting and landfarming alternatives, treatability studies results would provide optimum mix ratios of contaminated soil with admixtures, in addition to the required residence time to achieve cleanup levels. In addition, treatability studies could be performed for those technologies that were not retained for further analysis due to lack of demonstrated performance in Alaska (i.e., bioslurries and soil washing). These technologies might prove to be effective at a lower cost and have added benefits (i.e., beach sediments would not be rendered biologically neutral by these technologies, making it possible to restore the beach area to the original conditions). These data could also be applied to other FAA and multi-agency sites at the Annette Island Airport, thereby streamlining the overall remedial program approach.

It is also recommended that the data needs specified in Section 1.4 are filled prior to selecting a remedial alternative and entering the remedial design phase. These data will help ensure that cost-effective and efficient remedies are selected for the Main Dock Tank Farm.

5.0 REFERENCES

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APPENDIX A

COST ESTIMATE BACKUP

APPENDIX A-1

Global Cost Assumptions

A.1 GLOBAL COST ASSUMPTIONS

Order-of-magnitude costs were estimated for each remedial alternative, and are estimated to be accurate within –30% to +50%, per CERCLA guidance. Costs are rounded to the nearest ten thousand dollars, which is based upon the order-of-magnitude nature of the cost estimates. According to CERCLA guidance, costs are estimated only for the purposes of comparing remedial alternatives. Actual remediation costs could vary significantly from those prepared for this document, and will be determined during the remedial design phase. Also, additional data collected during future investigations could significantly effect the cost assumptions used to develop the cost estimates, including the volume of soil requiring remediation, the chemical composition in contaminated groundwater, and the length of time the remedial alternative is required to function.

Costs were calculated using the RACER/ENVEST™ cost estimating model, Version 3.2. The RACER/ENVEST™ model was developed by the Government specifically for estimating the costs of remedial approaches. The cost model was supplemented with site- or vendor-specific cost information, where available. Both capital and operation and maintenance (O&M) costs were calculated.

A.1.1 CAPITAL COSTS

Capital costs were calculated as separate components and then assembled for each remedial alternative. Additional contingency costs were added to the estimated capital costs produced by the RACER/ENVEST™ cost estimating model by applying the assumptions listed in Table A-1. Cost modifiers, which are additional costs related to the basic capital cost, were applied to the combined capital costs for each alternative. Cost modifiers were varied for some remedial alternatives based on alternative-specific factors.

Table A-1
Contingency and Cost Modifying Assumptions

Item	Percentage	Justification	Exceptions
Cost Contingency Assumptions			
Bid Contingencies	5%	• These contingency items were added to the capital costs due to the uncertainty associated with estimating costs in the absence of detailed remedial designs for the proposed remedial alternatives	• 75% for the groundwater monitoring alternative
Scope Contingencies	5%		• 50% for the groundwater monitoring alternative
Cost Modifying Assumptions			
Engineering Design	10%	• Standard cost estimating practice	• 5% for thermal desorption alternatives
Permitting and Legal	5%	• Funding to obtain necessary permits or demonstration that permits are not required	• 3% for thermal desorption alternatives
System Startup and Optimization	10%	• Funding to 'fine tune' remedial systems during the initial operational period	• 3% for thermal desorption alternatives • 7% for in-situ landfarming of beach sediments (RAO 2 only)
Bonding and Insurance	3%	• Standard cost estimating practice	• None
Construction Oversight	10%	• Standard cost estimating practice	• 5% for thermal desorption alternatives • 30% for the groundwater monitoring alternative
Field and Laboratory Testing	5%	• Funding to provide analytical, geotechnical, and other quality control testing during construction	• None
Reporting	10%	• Funding to prepare work plans, quality control plans, and other reports required for the construction effort	• 5% for thermal desorption alternatives • 30% for the groundwater monitoring alternative • 7% for in-situ landfarming of beach sediments (RAO 2 only)
Escalation	5%	• Assumes that construction will commence in mid 2001	• None

A.1.2 OPERATION AND MAINTENANCE COSTS

Operation and maintenance costs for each remedial alternative were calculated separately and then included as required for each remedial alternative. Present worth O&M costs were computed by multiplying the annual O&M cost by a present worth factor for each remedial alternative where O&M of the remedial alternative is required.

Present worth factors are a function of the interest rate and the total time in years the remedial alternative is expected to be in service. An interest rate of 5%, including the effects of inflation, is assumed for present worth analyses, which is based on CERCLA guidance. Table A-2 summarizes the cost modifying assumptions used to calculate O&M costs for each remedial alternative.

Table A-2
Operation and Maintenance Cost Modifying Assumptions

Item	Percentage	Justification	Exceptions
Insurance	5% of annual O&M	• Standard cost estimating practice	• None
Reserve	5% of annual O&M	• Funding to cover unanticipated costs during system O&M	• None
O&M Reporting	10% of annual O&M	• Funding required to document system operation, cost, and performance data	• None
Project Administration	15% of annual O&M	• Project management costs	• None
Project Review	5% of annual O&M	• Funding to provide regulatory agency review of remedial actions at 5-year intervals	• None
Repairs	20% of annual O&M	• Funding to cover periodic system break down, troubleshooting, and repair	• None

APPENDIX A-2

Alternative-Specific Cost Assumptions

JE JACOBS ENGINEERING GROUP INC.

CALCULATION SHEET

Project Name:	TERC Task Order 14, Remedial Alternatives for Site 42	**Prepared by:**	T. Dean
Project Number:	05M31412	**Date:**	Revised 14 Jan 00
Subject:	Approximate Soil and Sediment Volumes, Main Dock Tank Farm	**Reviewed by:**	

Given: Results from previous investigations.
Approximate area of impaced soil/sediment for each site.

Req'd: Determine volumes of soil requiring remediation.

Sol'n: Results of previous investigations indicate that fuel-related compounds are the priamry remedial drivers
Review of previous investigation results indicate that 12 of 18 samples collected exceed MIC cleanup levels (roughly 67%).
Also, approximate 33% of the samples collected exceed EPA Region 9 PRGs for industrial soil.

1 Percent of total volume requiring remediation for RAO 1 compliance: **33%**
2 Percent of total volume requiring remediation for RAO 2 compliance: **67%**

Calculation:

Site Number	Length (ft)	Width (ft)	Average Depth (ft)	Number of Areas	Total Volume (cy)	RAO 1 Volume (cy)	RAO 2 Volume (cy)
Soil							
42A	300	300	4	1	13,333	4,400	8,933
42D	50	50	1	4	370	122	248
42E	50	50	1	8	741	244	496
42F	100	50	2	1	370	122	248
42G	50	50	2	1	185	61	124
42H	0	0	0	0	-	-	-
42I	0	0	0	0	-	-	-
				Total Soil Volume:	15,000	**4,950**	**10,050**
Beach Sediment							
42B	1,000	300	2	1	22,222	7,333	14,889
42C	1,000	300	2	1	22,222	7,333	14,889
				Total Sediment Volume:	44,444	**14,667**	**29,778**

Soil Alternative 1 – Access Restrictions with Monitored Natural Attenuation

- To comply with RAO 1 (risk reduction), soil would be sampled annually for fuel-related compounds for a 15 year period.
- To comply with RAO 2 (comply with MIC cleanup levels), soil would be sampled annually for fuel-related compounds for a 30 year period.
- Approximately 20 samples would be collected during each sampling event. The number of samples would be constant regardless of which RAO is being satisfied.
- Samples would be collected using hand augers to a maximum depth of 5 feet bgs.
- The sampling team (2 ADEC-certified sampling technicians) would originate from Anchorage and take approximately 1 week to collect all required samples.
- All samples would be analyzed for GRO, DRO/RRO, BTEX, and PAHs. A standard 30-day turn-around-time is assumed.
- Administrative restrictions would only be required; no physical restrictions would be implemented.

Soil Alternative 2 – Excavation with Thermal Desorption

- For compliance with RAO 1 (risk reduction), approximately 5,000 bank cubic yards of soil would require remediation.
- For compliance with RAO 2 (comply with MIC cleanup levels), approximately 10,000 bank cubic yards of soil would require remediation.
- Soil excavations would be no more than 5 feet in depth; excavation into the saturated zone would not be conducted to avoid costs associated with restoring excavations and soil dewatering.
- Confirmation samples would be collected at a rate of one sample for every 250 square feet of excavation area and analyzed for GRO, DRO/RRO, and BTEX. Samples would be analyzed for PAHs at a rate of 10 percent.
- Soil would be treated in 2,000-cubic yard batches in one mobilization of the thermal desorption unit.
- Soil would be excavated, hauled to a centrally located treatment area located no more than 1,000 feet from excavation areas, and placed into a temporary holding cell prior to treatment.
- Treated soil would be returned to the excavation; no borrow material would be required.
- Treated soil would be sampled at a frequency of one sample for every 200 cubic yards and analyzed for GRO, DRO/RRO, and BTEX.
- Effluent generated from soil treatment operations would be treated using the selected groundwater treatment remedy; no separate treatment systems would be constructed.

Soil Alternative 3 – Excavation with Composting

- For compliance with RAO 1 (risk reduction), approximately 5,000 bank cubic yards of soil would require remediation.
- For compliance with RAO 2 (comply with MIC cleanup levels), approximately 10,000 bank cubic yards of soil would require remediation.
- Soil excavations would be no more than 5 feet in depth; excavation into the saturated zone would not be conducted to avoid costs associated with restoring excavations and soil dewatering.
- Confirmation samples would be collected at a rate of one sample for every 250 square feet of excavation area and analyzed for GRO, DRO/RRO, and BTEX. Samples would be analyzed for PAHs at a rate of 10 percent.
- The treatment process would involve the use of locally available wood chips from the inactive saw mill and fish waste from the local cannery. These materials are considered waste and would be obtained at no cost to the Government; however, loading and hauling costs are assumed.
- Soil would be treated in 2,000-cubic yard batches, with each batch requiring 18 months to meet cleanup levels. The compost would be tilled at a rate of 4 days per month with 2 passes per day.
- Borrow material would be imported to backfill excavations, with the borrow source no more than 5 miles from the excavation.
- A local labor force would be recruited and trained to conduct composting operations.
- Treated soil would be disposed of at a location no more than 1,000 feet from the treatment facility.
- Effluent generated from soil treatment operations would be treated using the selected groundwater treatment remedy; no separate treatment systems would be constructed.

Soil Alternative 4 – Excavation with Landfarming

- For compliance with RAO 1 (risk reduction), approximately 5,000 bank cubic yards of soil would require remediation.
- For compliance with RAO 2 (comply with MIC cleanup levels), approximately 10,000 bank cubic yards of soil would require remediation.
- Soil excavations would be no more than 5 feet in depth with a 4-foot average depth; excavation into the saturated zone would not be conducted to avoid costs associated with restoring excavations and soil dewatering.
- Confirmation samples would be collected at a rate of one sample for every 250 square feet of excavation area and analyzed for GRO, DRO/RRO, and BTEX. Samples would be analyzed for PAHs at a rate of 10 percent.
- The treatment process would involve the use of imported fertilizer applied to the soil at each tilling event.
- Soil would be treated in 2,000-cubic yard batches, with each batch requiring 18 months to meet cleanup levels. Material would be tilled at a rate of 4 days per month with 2 passes per day.
- Borrow material would be imported to backfill excavations, with the borrow source no more than 5 miles from the excavation.
- A local labor force would be recruited and trained to conduct landfarming operations.
- Treated soil would be disposed of at a location no more than 1,000 feet from the treatment facility.
- Effluent generated from soil treatment operations would be treated using the selected groundwater treatment remedy; no separate treatment systems would be constructed.

Beach Sediment Alternative 1 – Access Restrictions with Monitored Natural Attenuation

- To comply with RAO 1(risk reduction), beach sediments would be sampled annually for fuel-related compounds for a 15 year period.
- To comply with RAO 2 (comply with MIC cleanup levels), beach sediments would be sampled annually for fuel-related compounds for a 30 year period.
- Samples would be from 6 locations on an annual basis and sampled for GRO, DRO/RRO, BTEX, and PAHs. The number of samples would be constant regardless of which RAO is being satisfied. A standard 30-day turn-around-time is assumed.
- The sampling team (2 ADEC-certified sampling technicians) would originate from Anchorage and take approximately 2 days to collect all required samples.
- Administrative restrictions would only be required; no physical restrictions would be implemented.

Beach Sediment Alternative 2 – Excavation, Dewatering, and Treatment

- For compliance with RAO 1 (risk reduction), approximately 15,000 bank cubic yards of soil would require remediation.
- For compliance with RAO 2 (comply with MIC cleanup levels), approximately 30,000 bank cubic yards of soil would require remediation.
- Beach sediments are assumed to consist of well-graded sands with few fines.
- Beach sediment would only be excavated in areas above the low tide level; no sub-tidal excavations would be performed.
- Beach sediment excavations would be no more than 2 feet in depth; excavation into the saturated zone would not be conducted to avoid costs associated with restoring excavations and soil dewatering.
- Confirmation samples would be collected at a rate of one sample for every 1,000 square feet of excavation area and analyzed for GRO, DRO/RRO, and BTEX. Samples would be analyzed for PAHs at a rate of 10 percent.
- Soil would be treated in 2,000-cubic yard batches. Thermal desorption is used as the default treatment technology.
- Soil would be excavated, hauled to a centrally located treatment area located roughly 1,000 feet from excavation areas, and placed into a temporary holding cell prior to treatment.
- Treated soil would not be returned to the beach (rendered biologically neutral following treatment). A suitable soil disposal site would be located in the immediate area.
- Treated soil would be sampled at a frequency of one sample for every 200 cubic yards and analyzed for GRO, DRO/RRO, and BTEX.
- Effluent generated from dewatering and treatment operations would be treated using the selected groundwater treatment remedy; no separate treatment systems would be constructed.

Beach Sediment Alternative 3 – Landfarming

- 2,000 feet of beach front on either side of Main Dock would be tilled to a depth of 2 feet bgs, and would extend to the low tide mark (approximately 300 feet). It is assumed that it is cost effective to till the entire beach rather than selected areas regardless of which RAO is being complied with.
- The beach would be tilled weekly for a period of 12 weeks for RAO 1 compliance; compliance with RAO 2 would require a tilling period of 24 weeks.
- For RAO2, a sheet piling containment structure is assumed to provide additional protection of environmental receptors in Tamgas Harbor. The sheet piling would be installed along the 2,000 feet of beachfront, installed at a distance of 500 feet from the high tide mark, and to a depth of 30 feet. The installation of the sheet piling may be impeded by the presence of shallow bedrock,. which is inferred from bedrock outcrops present along the beach.
- No addition of nutrients, water, or non-indigenous microbes would be required.
- Samples would be collected once at the end of the tilling period at a frequency of 1 sample for every 2,000 square feet remediated. Samples would be analyzed for GRO, DRO/RRO, and BTEX. Samples would be collected for PAH analyses at a rate of 10 percent.
- Local labor would be recruited and trained to conduct tilling operations.

Water Alternative 1 – Access Restrictions with Monitored Natural Attenuation

- Monitor wells would be installed at 12 strategically placed locations.
- Monitor wells would be installed to a depth of 10 feet bgs (to a clay layer believed to be present across the site) with a five-foot screened interval.
- To comply with RAO 1, (risk reduction) it is assumed that the monitor wells would be sampled annually for a period of 15 years.
- To comply with RAO 2, (MIC cleanup level compliance) it is assumed that the monitor wells would be sampled annually for a period of 30 years.
- Samples would be analyzed for GRO, DRO/RRO, BTEX, PAHs.
- Samples would also be collected for monitored natural attenuation parameters, including metals and ions.
- The sampling team (2 ADEC-certified sampling technicians) would originate from Anchorage and take approximately 1 week to collect all required samples.
- Administrative restrictions would only be required; no physical restrictions would be implemented.

Water Alternative 2 – Interception Trench, Constructed Wetlands Treatment, and Underground Injection

- The groundwater collection system is assumed to consist of two separate intercept trenches, each having a length of 250 lineal feet. The collection array would be equipped with product separation equipment.
- An additional oil/water separator would be installed prior to influent entering the wetland area.
- The constructed wetland area is assumed to require a total area of 10,000 square feet, with a water depth of 3 feet, and a maximum flow rate of 150 gpm. A minimum hydraulic residence time of 1 day is assumed to be required to obtain water discharge criteria.
- To comply with RAO 1, (risk reduction) it is assumed that the system would be operated for a period of 15 years.
- To comply with RAO 2, (MIC cleanup level compliance) it is assumed that the system would be operated for a period of 30 years.
- Treated effluent would be discharged through six underground injection wells. Each well would have a maximum discharge capacity of 25 gpm. Water would be discharged below the clay layer suspected to be present across the site -- the wells would be installed to a maximum depth of 40 feet with a 20-foot screened interval.
- Influent and effluent would be sampled once per month and analyzed for BTEX and PAHs (ADEC water quality requirements).
- Local labor would be recruited and trained to conduct system operations.

Water Alternative 3 – Interception Trench, Carbon Adsorption, and Underground Injection

- The groundwater collection system is assumed to consist of two separate intercept trenches, each having a length of 250 lineal feet. The collection array would be equipped with product separation equipment.
- The water treatment system is assume to consist of an oil/water separator to help extent carbon life, carbon treatment, and effluent polishing using an additional carbon canister to ensure compliance with discharge requirements. The carbon is assumed to require changing every three month for the life of the system.
- To comply with RAO 1, (risk reduction) it is assumed that the system would be operated for a period of 15 years.
- To comply with RAO 2, (MIC cleanup level compliance) it is assumed that the system would be operated for a period of 30 years.
- Treated effluent would be discharged through six underground injection wells. Each well would have a maximum discharge capacity of 25 gpm. Water would be discharged below the clay layer suspected to be present across the site -- the wells would be installed to a maximum depth of 40 feet with a 20-foot screened interval.
- Influent and effluent would be sampled once per month and analyzed for BTEX and PAHs (ADEC water quality requirements).
- Local labor would be recruited and trained to conduct system operations.

Water Alternative 4 – Surface Water Diversion, Water Treatment Through Selected Groundwater Treatment System

- Sheet piling is assumed to be installed to a total depth of 15 feet bgs – just past the clay layer suspected to be present across the site.
- A total length of 1,000 lineal feet of diversion structure is assumed, and would be placed at strategic locations across the site to prevent uncontaminated shallow groundwater from becoming contaminated.
- Minimal replacement of sheet piling is assumed due to corrosion. The system is assumed to be required for the total duration of groundwater treatment remedies.
- No sampling or significant maintenance would be required.

Water Alternative 5 – Oxygen-Releasing Compounds

- To comply with RAO 1, (risk reduction) it is assumed that the system would be operated for a period of 5 years.
- To comply with RAO 2, (MIC cleanup level compliance) it is assumed that the system would be operated for a period of 10 years.
- 48 wells are assumed, and would be installed to a total depth of 10 feet bgs. Hydrogen peroxide is assumed as the oxygen-releasing compound, and would be applied at a rate of approximately 1 pound per well per day (50% solution H_2O_2).
- 24 monitor wells would be installed down gradient of the injection wells. The wells would be sampled quarterly for the life of the system and analyzed for dissolved oxygen, GRO, DRO/RRO, BTEX, and PAHs.
- Local labor would be recruited and trained to conduct system operations.

APPENDIX A-3

Remedial Alternative Cost Summary – RAO Number 1 Compliance

Remedial Alternative Cost Summary -- Compliance with Remedial Action Objective 1

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
Soil Alternative 1 -- Monitored Natural Attenuation	$0	$352,357	$352,357
Soil Alternative 2 -- Excavation with Thermal Desorption	$1,317,756	$0	$1,317,756
Soil Alternative 3 -- Excavation with Composting	$869,000	$0	$869,000
Soil Alternative 4 -- Excavation with Landfarming	$1,094,940	$0	$1,094,940
Sediment Alternative 1 -- Monitored Natural Attenuation	$0	$176,178	$176,178
Sediment Alternative 2 -- Excavation with Thermal Desorption	$5,704,380	$0	$5,704,380
Sediment Alternative 3 -- In-Situ Landfarming	$1,008,040	$0	$1,008,040
Water Alternative 1 -- Monitored Natural Attenuation	$93,555	$340,612	$434,167
Water Alternative 2 -- Constructed Wetlands	$1,329,570	$2,501,734	$3,831,304
Water Alternative 3 -- Carbon Absorption	$771,672	$4,134,321	$4,905,993
Water Alternative 4 -- Diversion	$535,304	$58,726	$594,030
Water Alternative 5 -- Oxygen-Releasing Compounds	$877,690	$1,104,447	$1,982,137

Estimated Costs for Soil Alternative 1 -- Monitored Natural Attenuation

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Monitored Natural Attenuation		$0
Construction Subtotal		**$0**
Bid Contingencies (% of Construction Subtotal)	5.0%	$0
Scope Contingencies (% of Construction Subtotal)	5.0%	$0
Construction Total		**$0**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$0
Permitting and Legal (% of Construction Total)	5.0%	$0
Startup and Shakedown (% of Construction Total)	0.0%	$0
Bonding and Insurance (% of Construction Total)	3.0%	$0
Construction Oversight (% of Construction Total)	10.0%	$0
Field and Laboratory Testing (% of Construction Total)	5.0%	$0
Reporting (% of Construction Total)	10.0%	$0
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$0
Total Capital Cost		**$0**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Monitored Natural Attenuation		$30,000	15	8.9658	$268,974.71
O&M Subtotal		**$30,000**			**$268,975**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Monitored Natural Attenuation	31%	$9,300	15	8.9658	$83,382
Total Operation and Maintenance Costs					**$352,357**

NET PRESENT WORTH	
Capital Costs	$0
Operation and Maintenance Present Worth	$352,357
Total Alternative Cost	**$352,357**

Estimated Costs for Soil Alternative 2, Excavation with Thermal Desorption

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Excavation with Thermal Desorption		$894,000
Construction Subtotal		**$894,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$44,700
Scope Contingencies (% of Construction Subtotal)	5.0%	$44,700
Construction Total		**$983,400**
Other Direct Costs		
Engineering Design (% of Construction Total)	5.0%	$49,170
Permitting and Legal (% of Construction Total)	3.0%	$29,502
Startup and Shakedown (% of Construction Total)	3.0%	$29,502
Bonding and Insurance (% of Construction Total)	3.0%	$29,502
Construction Oversight (% of Construction Total)	5.0%	$49,170
Field and Laboratory Testing (% of Construction Total)	5.0%	$49,170
Reporting (% of Construction Total)	5.0%	$49,170
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$49,170
Total Capital Cost		**$1,317,756**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Excavation with Thermal Desorption		$0	0	0.0000	$0
O&M Subtotal		**$0**			**$0**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Excavation with Thermal Desorption	31%	$0	0	0.0000	$0
Total Operation and Maintenance Costs					**$0**

NET PRESENT WORTH	
Capital Costs	$1,317,756
Operation and Maintenance Present Worth	$0
Total Alternative Cost	**$1,317,756**

Estimated Costs for Soil Alternative 3, Excavation with Composting

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Excavation with Composting		$500,000
Construction Subtotal		**$500,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$25,000
Scope Contingencies (% of Construction Subtotal)	5.0%	$25,000
Construction Total		**$550,000**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$55,000
Permitting and Legal (% of Construction Total)	5.0%	$27,500
Startup and Shakedown (% of Construction Total)	10.0%	$55,000
Bonding and Insurance (% of Construction Total)	3.0%	$16,500
Construction Oversight (% of Construction Total)	10.0%	$55,000
Field and Laboratory Testing (% of Construction Total)	5.0%	$27,500
Reporting (% of Construction Total)	10.0%	$55,000
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$27,500
Total Capital Cost		**$869,000**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Excavation with Composting		$0	0	0.0000	$0
O&M Subtotal		**$0**			**$0**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Excavation with Composting	31%	$0	0	0.0000	$0
Total Operation and Maintenance Costs					**$0**

NET PRESENT WORTH	
Capital Costs	$869,000
Operation and Maintenance Present Worth	$0
Total Alternative Cost	**$869,000**

Estimated Costs for Soil Alternative 4, Excavation with Landfarming

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Excavation with Landfarming		$630,000
Construction Subtotal		**$630,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$31,500
Scope Contingencies (% of Construction Subtotal)	5.0%	$31,500
Construction Total		**$693,000**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$69,300
Permitting and Legal (% of Construction Total)	5.0%	$34,650
Startup and Shakedown (% of Construction Total)	10.0%	$69,300
Bonding and Insurance (% of Construction Total)	3.0%	$20,790
Construction Oversight (% of Construction Total)	10.0%	$69,300
Field and Laboratory Testing (% of Construction Total)	5.0%	$34,650
Reporting (% of Construction Total)	10.0%	$69,300
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$34,650
Total Capital Cost		**$1,094,940**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Excavation with Landfarming		$0	0	0.0000	$0
O&M Subtotal		**$0**			**$0**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Excavation with Landfarming	31%	$0	0	0.0000	$0
Total Operation and Maintenance Costs					**$0**

NET PRESENT WORTH	
Capital Costs	$1,094,940
Operation and Maintenance Present Worth	$0
Total Alternative Cost	**$1,094,940**

Estimated Costs for Sediment Alternative 1, Monitored Natural Attenuation

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Monitored Natural Attenuation		$0
Construction Subtotal		**$0**
Bid Contingencies (% of Construction Subtotal)	5.0%	$0
Scope Contingencies (% of Construction Subtotal)	5.0%	$0
Construction Total		**$0**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$0
Permitting and Legal (% of Construction Total)	5.0%	$0
Startup and Shakedown (% of Construction Total)	10.0%	$0
Bonding and Insurance (% of Construction Total)	3.0%	$0
Construction Oversight (% of Construction Total)	10.0%	$0
Field and Laboratory Testing (% of Construction Total)	5.0%	$0
Reporting (% of Construction Total)	10.0%	$0
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$0
Total Capital Cost		**$0**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Monitored Natural Attenuation		$15,000	15	8.9658	$134,487
O&M Subtotal		**$15,000**			**$134,487**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Monitored Natural Attenuation	31%	$4,650	15	8.9658	$41,691
Total Operation and Maintenance Costs					**$176,178**

NET PRESENT WORTH	
Capital Costs	$0
Operation and Maintenance Present Worth	$176,178
Total Alternative Cost	**$176,178**

Estimated Costs for Sediment Alternative 2, Beach Sediment Dredging and Thermal Desorption

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Dredging & Dewatering with Thermal Desorption		$3,870,000
Construction Subtotal		**$3,870,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$193,500
Scope Contingencies (% of Construction Subtotal)	5.0%	$193,500
Construction Total		**$4,257,000**
Other Direct Costs		
Engineering Design (% of Construction Total)	5.0%	$212,850
Permitting and Legal (% of Construction Total)	3.0%	$127,710
Startup and Shakedown (% of Construction Total)	3.0%	$127,710
Bonding and Insurance (% of Construction Total)	3.0%	$127,710
Construction Oversight (% of Construction Total)	5.0%	$212,850
Field and Laboratory Testing (% of Construction Total)	5.0%	$212,850
Reporting (% of Construction Total)	5.0%	$212,850
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$212,850
Total Capital Cost		**$5,704,380**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Dredging & Dewatering with Thermal Desorption		$0	0	0.0000	$0
O&M Subtotal		**$0**			**$0**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Dredging & Dewatering with Thermal Desorption	31%	$0	0	0.0000	$0
Total Operation and Maintenance Costs					**$0**

NET PRESENT WORTH	
Capital Costs	$5,704,380
Operation and Maintenance Present Worth	$0
Total Alternative Cost	**$5,704,380**

Estimated Costs for Sediment Alternative 3, Landfarming

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Landfarming		$580,000
Construction Subtotal		**$580,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$29,000
Scope Contingencies (% of Construction Subtotal)	5.0%	$29,000
Construction Total		**$638,000**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$63,800
Permitting and Legal (% of Construction Total)	5.0%	$31,900
Startup and Shakedown (% of Construction Total)	10.0%	$63,800
Bonding and Insurance (% of Construction Total)	3.0%	$19,140
Construction Oversight (% of Construction Total)	10.0%	$63,800
Field and Laboratory Testing (% of Construction Total)	5.0%	$31,900
Reporting (% of Construction Total)	10.0%	$63,800
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$31,900
Total Capital Cost		**$1,008,040**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Landfarming		$0	0	0.0000	$0
O&M Subtotal		**$0**			**$0**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Landfarming	31%	$0	0	0.0000	$0
Total Operation and Maintenance Costs					**$0**

NET PRESENT WORTH	
Capital Costs	$1,008,040
Operation and Maintenance Present Worth	$0
Total Alternative Cost	**$1,008,040**

Estimated Costs for Water Alternative 1, Monitored Natural Attenuation

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Monitored Natural Attenuation		$21,000
Construction Subtotal		**$21,000**
Bid Contingencies (% of Construction Subtotal)	75.0%	$15,750
Scope Contingencies (% of Construction Subtotal)	50.0%	$10,500
Construction Total		**$47,250**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$4,725
Permitting and Legal (% of Construction Total)	5.0%	$2,363
Startup and Shakedown (% of Construction Total)	10.0%	$4,725
Bonding and Insurance (% of Construction Total)	3.0%	$1,418
Construction Oversight (% of Construction Total)	30.0%	$14,175
Field and Laboratory Testing (% of Construction Total)	5.0%	$2,363
Reporting (% of Construction Total)	30.0%	$14,175
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$2,363
Total Capital Cost		**$93,555**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Monitored Natural Attenuation		$29,000	15	8.9658	$260,009
O&M Subtotal		**$29,000**			**$260,009**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Monitored Natural Attenuation	31%	$8,990	15	8.9658	$80,603
Total Operation and Maintenance Costs					**$340,612**

NET PRESENT WORTH	
Capital Costs	$93,555
Operation and Maintenance Present Worth	$340,612
Total Alternative Cost	**$434,167**

Estimated Costs for Water Alternative 2, Constructed Wetlands

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Constructed Wetlands		$765,000
Construction Subtotal		**$765,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$38,250
Scope Contingencies (% of Construction Subtotal)	5.0%	$38,250
Construction Total		**$841,500**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$84,150
Permitting and Legal (% of Construction Total)	5.0%	$42,075
Startup and Shakedown (% of Construction Total)	10.0%	$84,150
Bonding and Insurance (% of Construction Total)	3.0%	$25,245
Construction Oversight (% of Construction Total)	10.0%	$84,150
Field and Laboratory Testing (% of Construction Total)	5.0%	$42,075
Reporting (% of Construction Total)	10.0%	$84,150
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$42,075
Total Capital Cost		**$1,329,570**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Constructed Wetlands		$213,000	15	8.9658	$1,909,720
O&M Subtotal		**$213,000**			**$1,909,720**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Constructed Wetlands	31%	$66,030	15	8.9658	$592,013
Total Operation and Maintenance Costs					**$2,501,734**

NET PRESENT WORTH	
Capital Costs	$1,329,570
Operation and Maintenance Present Worth	$2,501,734
Total Alternative Cost	**$3,831,304**

Estimated Costs for Water Alternative 3, Carbon Absorption

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Carbon Absorption		$444,000
Construction Subtotal		**$444,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$22,200
Scope Contingencies (% of Construction Subtotal)	5.0%	$22,200
Construction Total		**$488,400**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$48,840
Permitting and Legal (% of Construction Total)	5.0%	$24,420
Startup and Shakedown (% of Construction Total)	10.0%	$48,840
Bonding and Insurance (% of Construction Total)	3.0%	$14,652
Construction Oversight (% of Construction Total)	10.0%	$48,840
Field and Laboratory Testing (% of Construction Total)	5.0%	$24,420
Reporting (% of Construction Total)	10.0%	$48,840
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$24,420
Total Capital Cost		**$771,672**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Carbon Absorption		$352,000	15	8.9658	$3,155,970
O&M Subtotal		**$352,000**			**$3,155,970**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Carbon Absorption	31%	$109,120	15	8.9658	$978,351
Total Operation and Maintenance Costs					**$4,134,321**

NET PRESENT WORTH	
Capital Costs	$771,672
Operation and Maintenance Present Worth	$4,134,321
Total Alternative Cost	**$4,905,993**

Estimated Costs for Water Alternative 4, Diversion

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Diversion		$308,000
Construction Subtotal		**$308,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$15,400
Scope Contingencies (% of Construction Subtotal)	5.0%	$15,400
Construction Total		**$338,800**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$33,880
Permitting and Legal (% of Construction Total)	5.0%	$16,940
Startup and Shakedown (% of Construction Total)	10.0%	$33,880
Bonding and Insurance (% of Construction Total)	3.0%	$10,164
Construction Oversight (% of Construction Total)	10.0%	$33,880
Field and Laboratory Testing (% of Construction Total)	5.0%	$16,940
Reporting (% of Construction Total)	10.0%	$33,880
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$16,940
Total Capital Cost		**$535,304**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Diversion		$5,000	15	8.9658	$44,829
O&M Subtotal		**$5,000**			**$44,829**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Diversion	31%	$1,550	15	8.9658	$13,897
Total Operation and Maintenance Costs					**$58,726**

NET PRESENT WORTH	
Capital Costs	$535,304
Operation and Maintenance Present Worth	$58,726
Total Alternative Cost	**$594,030**

Estimated Costs for Water Alternative 5, Oxygen-Releasing Compounds

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Oxygen-Releasing Compounds		$505,000
Construction Subtotal		**$505,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$25,250
Scope Contingencies (% of Construction Subtotal)	5.0%	$25,250
Construction Total		**$555,500**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$55,550
Permitting and Legal (% of Construction Total)	5.0%	$27,775
Startup and Shakedown (% of Construction Total)	10.0%	$55,550
Bonding and Insurance (% of Construction Total)	3.0%	$16,665
Construction Oversight (% of Construction Total)	10.0%	$55,550
Field and Laboratory Testing (% of Construction Total)	5.0%	$27,775
Reporting (% of Construction Total)	10.0%	$55,550
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$27,775
Total Capital Cost		**$877,690**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Oxygen-Releasing Compounds		$207,000	5	4.0729	$843,090
O&M Subtotal		**$207,000**			**$843,090**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Oxygen-Releasing Compounds	31%	$64,170	5	4.0729	$261,358
Total Operation and Maintenance Costs					**$1,104,447**

NET PRESENT WORTH	
Capital Costs	$877,690
Operation and Maintenance Present Worth	$1,104,447
Total Alternative Cost	**$1,982,137**

APPENDIX A-4

Remedial Alternative Cost Summary – RAO Number 2 Compliance

Remedial Alternative Cost Summary -- Compliance with Remedial Action Objective 2

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
Soil Alternative 1 -- Monitored Natural Attenuation	$0	$475,674	$475,674
Soil Alternative 2 -- Excavation with Thermal Desorption	$2,448,314	$0	$2,448,314
Soil Alternative 3 -- Excavation with Composting	$1,421,684	$0	$1,421,684
Soil Alternative 4 -- Excavation with Landfarming	$1,388,662	$0	$1,388,662
Sediment Alternative 1 -- Monitored Natural Attenuation	$0	$237,837	$237,837
Sediment Alternative 2 -- Excavation with Thermal Desorption	$10,281,150	$0	$10,281,150
Sediment Alternative 3 -- In-Situ Landfarming	$4,801,940	$0	$4,801,940
Water Alternative 1 -- Monitored Natural Attenuation	$93,555	$459,818	$553,373
Water Alternative 2 -- Constructed Wetlands	$1,329,570	$3,377,285	$4,706,855
Water Alternative 3 -- Carbon Absorption	$771,672	$5,581,241	$6,352,913
Water Alternative 4 -- Diversion	$535,304	$79,279	$614,583
Water Alternative 5 -- Oxygen-Releasing Compounds	$877,690	$1,882,768	$2,760,458

Estimated Costs for Soil Alternative 1 -- Monitored Natural Attenuation

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Monitored Natural Attenuation		$0
Construction Subtotal		**$0**
Bid Contingencies (% of Construction Subtotal)	5.0%	$0
Scope Contingencies (% of Construction Subtotal)	5.0%	$0
Construction Total		**$0**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$0
Permitting and Legal (% of Construction Total)	5.0%	$0
Startup and Shakedown (% of Construction Total)	0.0%	$0
Bonding and Insurance (% of Construction Total)	3.0%	$0
Construction Oversight (% of Construction Total)	10.0%	$0
Field and Laboratory Testing (% of Construction Total)	5.0%	$0
Reporting (% of Construction Total)	10.0%	$0
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$0
Total Capital Cost		**$0**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Monitored Natural Attenuation		$30,000	30	12.1037	$363,109.88
O&M Subtotal		**$30,000**			**$363,110**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Monitored Natural Attenuation	31%	$9,300	30	12.1037	$112,564
Total Operation and Maintenance Costs					**$475,674**

NET PRESENT WORTH	
Capital Costs	$0
Operation and Maintenance Present Worth	$475,674
Total Alternative Cost	**$475,674**

Estimated Costs for Soil Alternative 2, Excavation with Thermal Desorption

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Excavation with Thermal Desorption		$1,661,000
Construction Subtotal		**$1,661,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$83,050
Scope Contingencies (% of Construction Subtotal)	5.0%	$83,050
Construction Total		**$1,827,100**
Other Direct Costs		
Engineering Design (% of Construction Total)	5.0%	$91,355
Permitting and Legal (% of Construction Total)	3.0%	$54,813
Startup and Shakedown (% of Construction Total)	3.0%	$54,813
Bonding and Insurance (% of Construction Total)	3.0%	$54,813
Construction Oversight (% of Construction Total)	5.0%	$91,355
Field and Laboratory Testing (% of Construction Total)	5.0%	$91,355
Reporting (% of Construction Total)	5.0%	$91,355
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$91,355
Total Capital Cost		**$2,448,314**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Excavation with Thermal Desorption		$0	0	0.0000	$0
O&M Subtotal		**$0**			**$0**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Excavation with Thermal Desorption	31%	$0	0	0.0000	$0
Total Operation and Maintenance Costs					**$0**

NET PRESENT WORTH	
Capital Costs	$2,448,314
Operation and Maintenance Present Worth	$0
Total Alternative Cost	**$2,448,314**

Estimated Costs for Soil Alternative 3, Excavation with Composting

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Excavation with Composting		$818,000
Construction Subtotal		**$818,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$40,900
Scope Contingencies (% of Construction Subtotal)	5.0%	$40,900
Construction Total		**$899,800**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$89,980
Permitting and Legal (% of Construction Total)	5.0%	$44,990
Startup and Shakedown (% of Construction Total)	10.0%	$89,980
Bonding and Insurance (% of Construction Total)	3.0%	$26,994
Construction Oversight (% of Construction Total)	10.0%	$89,980
Field and Laboratory Testing (% of Construction Total)	5.0%	$44,990
Reporting (% of Construction Total)	10.0%	$89,980
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$44,990
Total Capital Cost		**$1,421,684**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Excavation with Composting		$0	0	0.0000	$0
O&M Subtotal		**$0**			**$0**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Excavation with Composting	31%	$0	0	0.0000	$0
Total Operation and Maintenance Costs					**$0**

NET PRESENT WORTH	
Capital Costs	$1,421,684
Operation and Maintenance Present Worth	$0
Total Alternative Cost	**$1,421,684**

Estimated Costs for Soil Alternative 4, Excavation with Landfarming

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Excavation with Landfarming		$799,000
Construction Subtotal		**$799,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$39,950
Scope Contingencies (% of Construction Subtotal)	5.0%	$39,950
Construction Total		**$878,900**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$87,890
Permitting and Legal (% of Construction Total)	5.0%	$43,945
Startup and Shakedown (% of Construction Total)	10.0%	$87,890
Bonding and Insurance (% of Construction Total)	3.0%	$26,367
Construction Oversight (% of Construction Total)	10.0%	$87,890
Field and Laboratory Testing (% of Construction Total)	5.0%	$43,945
Reporting (% of Construction Total)	10.0%	$87,890
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$43,945
Total Capital Cost		**$1,388,662**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Excavation with Landfarming		$0	0	0.0000	$0
O&M Subtotal		**$0**			**$0**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Excavation with Landfarming	31%	$0	0	0.0000	$0
Total Operation and Maintenance Costs					**$0**

NET PRESENT WORTH	
Capital Costs	$1,388,662
Operation and Maintenance Present Worth	$0
Total Alternative Cost	**$1,388,662**

Estimated Costs for Sediment Alternative 1, Monitored Natural Attenuation

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Monitored Natural Attenuation		$0
Construction Subtotal		**$0**
Bid Contingencies (% of Construction Subtotal)	5.0%	$0
Scope Contingencies (% of Construction Subtotal)	5.0%	$0
Construction Total		**$0**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$0
Permitting and Legal (% of Construction Total)	5.0%	$0
Startup and Shakedown (% of Construction Total)	10.0%	$0
Bonding and Insurance (% of Construction Total)	3.0%	$0
Construction Oversight (% of Construction Total)	10.0%	$0
Field and Laboratory Testing (% of Construction Total)	5.0%	$0
Reporting (% of Construction Total)	10.0%	$0
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$0
Total Capital Cost		**$0**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Monitored Natural Attenuation		$15,000	30	12.1037	$181,555
O&M Subtotal		**$15,000**			**$181,555**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Monitored Natural Attenuation	31%	$4,650	30	12.1037	$56,282
Total Operation and Maintenance Costs					**$237,837**

NET PRESENT WORTH	
Capital Costs	$0
Operation and Maintenance Present Worth	$237,837
Total Alternative Cost	**$237,837**

Estimated Costs for Sediment Alternative 2, Beach Sediment Dredging and Thermal Desorption

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Dredging & Dewatering with Thermal Desorption		$6,975,0
Construction Subtotal		**$6,975,0**
Bid Contingencies (% of Construction Subtotal)	5.0%	$348,7
Scope Contingencies (% of Construction Subtotal)	5.0%	$348,7
Construction Total		**$7,672,5**
Other Direct Costs		
Engineering Design (% of Construction Total)	5.0%	$383,6
Permitting and Legal (% of Construction Total)	3.0%	$230,1
Startup and Shakedown (% of Construction Total)	3.0%	$230,1
Bonding and Insurance (% of Construction Total)	3.0%	$230,1
Construction Oversight (% of Construction Total)	5.0%	$383,6
Field and Laboratory Testing (% of Construction Total)	5.0%	$383,6
Reporting (% of Construction Total)	5.0%	$383,6
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$383,6
Total Capital Cost		**$10,281,1**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Optio Present Wort**
Dredging & Dewatering with Thermal Desorption		$0	0	0.0000	
O&M Subtotal		**$0**			
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Dredging & Dewatering with Thermal Desorption	31%	$0	0	0.0000	
Total Operation and Maintenance Costs					

NET PRESENT WORTH	
Capital Costs	$10,281,1
Operation and Maintenance Present Worth	
Total Alternative Cost	**$10,281,1**

Estimated Costs for Sediment Alternative 3, Landfarming

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Landfarming		$2,990,000
Construction Subtotal		**$2,990,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$149,500
Scope Contingencies (% of Construction Subtotal)	5.0%	$149,500
Construction Total		**$3,289,000**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$328,900
Permitting and Legal (% of Construction Total)	7.0%	$230,230
Startup and Shakedown (% of Construction Total)	3.0%	$98,670
Bonding and Insurance (% of Construction Total)	3.0%	$98,670
Construction Oversight (% of Construction Total)	10.0%	$328,900
Field and Laboratory Testing (% of Construction Total)	5.0%	$164,450
Reporting (% of Construction Total)	3.0%	$98,670
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$164,450
Total Capital Cost		**$4,801,940**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Landfarming		$0	0	0.0000	$0
O&M Subtotal		**$0**			**$0**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Landfarming	31%	$0	0	0.0000	$0
Total Operation and Maintenance Costs					**$0**

NET PRESENT WORTH	
Capital Costs	$4,801,940
Operation and Maintenance Present Worth	$0
Total Alternative Cost	**$4,801,940**

Estimated Costs for Water Alternative 1, Monitored Natural Attenuation

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Monitored Natural Attenuation		$21,000
Construction Subtotal		**$21,000**
Bid Contingencies (% of Construction Subtotal)	75.0%	$15,750
Scope Contingencies (% of Construction Subtotal)	50.0%	$10,500
Construction Total		**$47,250**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$4,725
Permitting and Legal (% of Construction Total)	5.0%	$2,363
Startup and Shakedown (% of Construction Total)	10.0%	$4,725
Bonding and Insurance (% of Construction Total)	3.0%	$1,418
Construction Oversight (% of Construction Total)	30.0%	$14,175
Field and Laboratory Testing (% of Construction Total)	5.0%	$2,363
Reporting (% of Construction Total)	30.0%	$14,175
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$2,363
Total Capital Cost		**$93,555**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Monitored Natural Attenuation		$29,000	30	12.1037	$351,006
O&M Subtotal		**$29,000**			**$351,006**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Monitored Natural Attenuation	31%	$8,990	30	12.1037	$108,812
Total Operation and Maintenance Costs					**$459,818**

NET PRESENT WORTH	
Capital Costs	$93,555
Operation and Maintenance Present Worth	$459,818
Total Alternative Cost	**$553,373**

Estimated Costs for Water Alternative 2, Constructed Wetlands

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Constructed Wetlands		$765,000
Construction Subtotal		**$765,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$38,250
Scope Contingencies (% of Construction Subtotal)	5.0%	$38,250
Construction Total		**$841,500**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$84,150
Permitting and Legal (% of Construction Total)	5.0%	$42,075
Startup and Shakedown (% of Construction Total)	10.0%	$84,150
Bonding and Insurance (% of Construction Total)	3.0%	$25,245
Construction Oversight (% of Construction Total)	10.0%	$84,150
Field and Laboratory Testing (% of Construction Total)	5.0%	$42,075
Reporting (% of Construction Total)	10.0%	$84,150
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$42,075
Total Capital Cost		**$1,329,570**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Constructed Wetlands		$213,000	30	12.1037	$2,578,080
O&M Subtotal		**$213,000**			**$2,578,080**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Constructed Wetlands	31%	$66,030	30	12.1037	$799,205
Total Operation and Maintenance Costs					**$3,377,285**

NET PRESENT WORTH	
Capital Costs	$1,329,570
Operation and Maintenance Present Worth	$3,377,285
Total Alternative Cost	**$4,706,855**

Estimated Costs for Water Alternative 3, Carbon Absorption

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Carbon Absorption		$444,000
Construction Subtotal		**$444,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$22,200
Scope Contingencies (% of Construction Subtotal)	5.0%	$22,200
Construction Total		**$488,400**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$48,840
Permitting and Legal (% of Construction Total)	5.0%	$24,420
Startup and Shakedown (% of Construction Total)	10.0%	$48,840
Bonding and Insurance (% of Construction Total)	3.0%	$14,652
Construction Oversight (% of Construction Total)	10.0%	$48,840
Field and Laboratory Testing (% of Construction Total)	5.0%	$24,420
Reporting (% of Construction Total)	10.0%	$48,840
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$24,420
Total Capital Cost		**$771,672**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Carbon Absorption		$352,000	30	12.1037	$4,260,489
O&M Subtotal		**$352,000**			**$4,260,489**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Carbon Absorption	31%	$109,120	30	12.1037	$1,320,752
Total Operation and Maintenance Costs					**$5,581,241**

NET PRESENT WORTH	
Capital Costs	$771,672
Operation and Maintenance Present Worth	$5,581,241
Total Alternative Cost	**$6,352,913**

Estimated Costs for Water Alternative 4, Diversion

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Diversion		$308,000
Construction Subtotal		**$308,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$15,400
Scope Contingencies (% of Construction Subtotal)	5.0%	$15,400
Construction Total		**$338,800**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$33,880
Permitting and Legal (% of Construction Total)	5.0%	$16,940
Startup and Shakedown (% of Construction Total)	10.0%	$33,880
Bonding and Insurance (% of Construction Total)	3.0%	$10,164
Construction Oversight (% of Construction Total)	10.0%	$33,880
Field and Laboratory Testing (% of Construction Total)	5.0%	$16,940
Reporting (% of Construction Total)	10.0%	$33,880
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$16,940
Total Capital Cost		**$535,304**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Diversion		$5,000	30	12.1037	$60,518
O&M Subtotal		**$5,000**			**$60,518**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Diversion	31%	$1,550	30	12.1037	$18,761
Total Operation and Maintenance Costs					**$79,279**

NET PRESENT WORTH	
Capital Costs	$535,304
Operation and Maintenance Present Worth	$79,279
Total Alternative Cost	**$614,583**

Estimated Costs for Water Alternative 5, Oxygen-Releasing Compounds

CAPITAL COSTS		
Remedial Alternative	**Percentage**	**Capital Cost**
Oxygen-Releasing Compounds		$505,000
Construction Subtotal		**$505,000**
Bid Contingencies (% of Construction Subtotal)	5.0%	$25,250
Scope Contingencies (% of Construction Subtotal)	5.0%	$25,250
Construction Total		**$555,500**
Other Direct Costs		
Engineering Design (% of Construction Total)	10.0%	$55,550
Permitting and Legal (% of Construction Total)	5.0%	$27,775
Startup and Shakedown (% of Construction Total)	10.0%	$55,550
Bonding and Insurance (% of Construction Total)	3.0%	$16,665
Construction Oversight (% of Construction Total)	10.0%	$55,550
Field and Laboratory Testing (% of Construction Total)	5.0%	$27,775
Reporting (% of Construction Total)	10.0%	$55,550
Escalation (% of Construction Total, Based on Mid 2001 Start)	5.0%	$27,775
Total Capital Cost		**$877,690**

OPERATION AND MAINTENANCE					
Process Option		**Annual O&M Cost**	**Estimated Alternative Life Cycle (yr)**	**Present Worth Factor**	**Process Option Present Worth**
Oxygen-Releasing Compounds		$207,000	10	6.9431	$1,437,228
O&M Subtotal		**$207,000**			**$1,437,228**
Misc. O&M Costs (% Annual O&M Unless Otherwise Specified) **See Global Cost Assumptions For Details on Calculations**	**Percentage**				
Oxygen-Releasing Compounds	31%	$64,170	10	6.9431	$445,541
Total Operation and Maintenance Costs					**$1,882,768**

NET PRESENT WORTH	
Capital Costs	$877,690
Operation and Maintenance Present Worth	$1,882,768
Total Alternative Cost	**$2,760,458**